XC
.0497
#41
2004

COMPOSITAE NEWSLETTER

Number 41 **29 December 2004**

Scientific Editor: Bertil Nordenstam
Technical Editor: Gunnel Wirénius Nohlin
Published and distributed by The Swedish Museum of Natural History,
Department of Phanerogamic Botany,
P.O. Box 50007, SE-104 05 Stockholm, Sweden

ISSN 0284-8422

Contents

Mondin, C. A.: Two new species of *Smallanthus* (Asteraceae: Heliantheae) from Brazil 1

Kamel, Ehab Abdelrazik: Cytotaxonomical investigations of the Egyptian Compositae (Asteraceae): I – Cardueae and Cichorieae 9

Mukherjee, Sohban K. & B. Nordenstam: Diversity of carpopodial structure in the Asteraceae and its taxonomic significance 29

Bartoli, A. & R. D. Tortosa: Chromosome numbers in species of *Grindelia* (Asteraceae, Astereae) from the Meseta del Somuncura (Patagonia, Argentina) 51

Pruski, J. & A. Davies: On the lectotypification of *Chaetanthera* Ruiz & Pav. (Compositae: Mutisieae) 54

Wang, Li-Song & Hua Peng: Typification of the genus *Myriactis* Less. (Compositae: Astereae) 58

Davies, A. M. R., Pillukat, A. & P. Bodensteiner: Compositae type images from Munich (M & MSB): the INFOCOMP Project online 60

Watanabe, K.: Index to Chromosome Numbers in the Asteraceae on the Web 64

Anderberg, A. A.: Call for material of the Inuleae (incl. Plucheeae) 65

Book review: Antonio & Masi, The Sunflower Family In The Upper Midwest (by J. Pruski) 66

SYNTHESYS – EU-funded Integrated Infrastructure Initiative 68

New taxa published in this issue 70

Two new species of *Smallanthus* (Asteraceae: Heliantheae) from Brazil

CLÁUDIO A. MONDIN
Laboratório de Taxonomia Vegetal – Centro de Ciências da Saúde,
Universidade do Vale do Rio dos Sinos, Caixa Postal 275,
93001-970 –São Leopoldo, Rio Grande do Sul, Brazil
e-mail: mondin@bios.unisinos.br

Abstract

Recent efforts to survey the species of the tribe Heliantheae (Asteraceae) in State of Rio Grande do Sul, Brazil, have resulted in the recognition of two new species of *Smallanthus*, here described as *S. riograndensis* C. MONDIN and *S. araucariophilus* C. MONDIN. Both species are known only from Rio Grande do Sul.

Introduction

The genus *Smallanthus* MACK. contains about 20 species that occur from sea level to ca. 3000 m in elevation from Mexico to Central and South America, and for the most part are restricted to temperate regions. Members of the genus are erect herbs, shrubs, or trees to more than 12 m tall. According to WELLS (1965), ROBINSON (1978) and BREMER (1994), the morphological features that characterize *Smallanthus* are: stems terete, angular or canaliculate, to 20 cm thick; leaves simple or lobed, generally opposite, less commonly alternate, sessile or petiolate, the petiole sometimes winged; capitula solitary, paniculate or corymbose, radiate; involucral bracts in two to three rows, dimorphic: outer spreading, foliaceous; inner usually concave, the tip sometimes acuminate, enfolding the ray cypsela; ray florets carpellate, in one or rarely two series, yellow, white or orange-red; disk florets functionally staminate, corolla tubular, yellow or purplish; ray cypselas brown, purplish-black, or black, obovoid or spherical and slightly flattened laterally, or 3–5 angled, the angles sometimes winged; pappus absent.

Revisionary study of the South Brazilian species of Heliantheae, now in progress, has led to the recognition of two new species of *Smallanthus*. Both are endemic to northeastern Rio Grande do Sul State, Southern Brazil.

Description

Smallanthus riograndensis **C. Mondin, sp. nov.**

Type: Brazil. Rio Grande do Sul: Serra do Pinto, Mun. São Francisco de Paula, Tainhas, Aratinga, 27 Apr 2002, Mondin & Iob 2653 (holotype ICN, isotypes HASU, PACA). Figs. 1, 3.

Herba annua erecta robusta usque 3 m alta; caules teretes, glabri vel puberuli. Folia opposita petiolata membranacea trinervata, adaxiali facie scabra, dorso puberula et glandulo-punctata; folia superiora ovata, serrata vel dentata, petiolo saepe alato, inferiora deltoidea lobato-dentata acuminata, base truncata, usque ad 35 cm longa et 20 cm lata. Inflorescentia terminalis et axillis foliorum, laxe cymosa; pedunculi 1–4 cm longi pilosi. Involucri bracteae 3-seriatae; exteriores 5–6, foliaceae, ovatae vel obovatae usque lanceolatae vel oblanceolatae, apice acuto vel obtuso, 7–15 mm longae, 3–7 mm latae; interiores 23–29, concavae, cypselas applicatae, lanceolatae, dorso glandulosae apice pilosae, 5–7 mm longae, 1.5–2.5 mm latae, acuminatae; receptaculum planum pilosum, paleis membranaceis lanceolatis, 5–7 mm longis, 1–2 mm latis, acuminatis, margine pilosis. Flores radii ca. 23–29, biseriati feminei; corolla 3–6 mm longa, pallide flava, tubus 1–2 mm longus, glanduloso-pilosus, ligula 3–5-nervata, 2–4.5 mm longa, 0.8–1.5 mm lata, bidentata vel integra, dorso glandulosa et puberula; stylus 3–4 mm longus, rami ca. 1.2 mm longi glabri; flores disci ca. 42–56 submasculi; corolla tubulosa 4.5–5 mm longa flava puberula et glandulosa, tubus 1.7–2 mm longus 5-lobatus, lobis deltoideis glandulosis 0.5–0.8 mm longis; antherae nigrescentes 1.2–1.5 mm longae, appendice antherarum deltoideo; stylus brevis 2-lobatus, apice piloso, 4–5 mm longus. Cypselae nigrae obovoideae striatae glabrae ca. 3 mm longae et 2 mm latae. Pappus nullus.

Erect herb 3 m tall; stems terete, canaliculate, hollow, glabrous or puberulent. Leaves opposite, petiolate, membranaceous, triplinerved, adaxial surface scabrous, abaxial surface sparsely puberulent and glandular-punctate chiefly on veins; upper leaves ovate, serrate or dentate, the petiole sometimes winged; lower leaves triangular, lobate dentate, acuminate, the base truncate, abruptly tapering to the lower winged lobate portion, to 35 cm long and 20 cm wide. Inflorescence terminal and also axillary from distal nodes, cymose, 2–9-headed; peduncles ca. 1–4 cm long, pilose. Involucral bracts in three rows, dimorphic: outer 5–6, spreading, foliaceous, ovate or obovate to lanceolate or oblanceolate, apically acute or obtuse, 7–15 mm long, 3–7 mm wide, with ca. 5–7 parallel nerves, glabrous, the margins pilose; inner 23–29, concave, enfolding the ray cypselas, lanceolate, abaxially glandular and pilose above, 5–7 mm long, 1.5–2.5 mm wide, acuminate to long-acuminate; receptacle flattened, pilose, paleaceous, the paleae membranaceous, lanceolate, 5–7 mm long, 1–2 mm wide, apically acuminate, the margins pilose. Ray florets ca. 23–29 in 2 series, carpellate; corolla 3–6 mm long, pale yellow, the tube 1–2 mm long, glandular-pilose, the ligule 3–5-nerved, 2–4.5 mm

long, 0.8–1.5 mm wide, bidentate or entire, abaxially glandular-punctate and puberulent; style 3–4 mm long, branches ca. 1.2 mm long, glabrous; disk florets ca. 42–56, functionally male; corolla tubular, 4.5–5 mm long, yellow, puberulent and glandular-punctate, tube 1.7–2 mm long, limb well wider than tube, throat 2.2–2.5 mm long, lobes 5, triangular, 0.5–0.8 mm long; anthers black, 1.2–1.5 mm long, apical appendage deltoid; style shortly 2-lobed and pilose apically, 4–5 mm long. Cypselas black, compressed-obovoid, striate, glabrous, ca. 3 mm long and 2 mm wide. Pappus absent.

Paratypes: Brazil. Rio Grande do Sul: Marcelino Ramos, mata na barranca do rio Uruguai, 2 Mar 1989, JARENKOW 1260 (PEL); Serra do Pinto, Mun. São Francisco de Paula, Tainhas, Aratinga, 11 Apr 2002, IOB, SILVEIRA & ESTRADA 234 (HASU); Serra do Pinto, Mun. São Francisco de Paula, Tainhas, Aratinga, 27 Apr 2002, MONDIN & IOB 2654 (HASU, ICN); Serra do Pinto, Mun. São Francisco de Paula, Tainhas, Aratinga, a 8 km da vila, em direção à Terra de Areia, 31 Jan 2003, MONDIN 2922 (HASU).

Distribution and ecology: This species is known from the Atlantic and Subtropical Rain Forests in the northeastern Rio Grande do Sul, Brazil. It occurs from 300 to 500 m in elevation and has been collected in flower in January, March and April.

Both *Smallanthus riograndensis* and the following *S. araucariophilus* initially seem close to *S. connatus* (SPRENG.) H. ROB., also of Southern Brazil, because of the leaf shape, size and the biseriate ray florets. The latter species differs, however, by the basally connate leaves and dark purple disk florets. The two new species seem morphologically very close, but they are notably distinct in the tips, colour and size of the rays and in the indumentum of the leaves.

Smallanthus araucariophilus **C. MONDIN, sp. nov.**

Type: Brazil. Rio Grande do Sul: Cambará do Sul, na estrada para São José dos Ausentes, 13 Feb 2002, MONDIN & IOB 2553 (holotype ICN, isotypes HASU, PACA). Figs. 2, 3.

Herba annua erecta robusta usque 3 m alta; caules teretes pilosi. Folia opposita petiolata membranacea trinervata, facie adaxiali puberula, dorso puberula usque pilosa et distincte glandulo-punctata; petiolo alato lobato, folia superiora ovata dentata, inferiora deltoidea lobato-dentata acuminata, base truncata, usque ad 35 cm longa et 26 cm lata. Inflorescentia terminalis et axillis foliorum, laxe cymosa; pedunculi 1–7 cm longi glanduloso-pilosi. Involucri bracteae 2–3-seriatae: exteriores 5, foliaceae, ovatae usque lanceolatae, apice acuto vel acuminato, 6–12 mm longae, 3–7 mm latae; interiores 17–26, concavae, cypselas applicatae, ovatae usque lanceolatae, dorso glandulosae, dense pilosae, 5–9 mm longae, 2–3 mm latae, acuminatae; receptaculum planum, paleis membranaceis lanceolatis, 5–6 mm longis, 1–2 mm latis, acuminatis, margine pilosis. Flores radii ca. 17–26, 1-2-seriati feminei; corolla 7–10 mm longa, flava; tubus 1.5–2.5 mm longus glanduloso-pilosus, ligula 5–8-nervata, 5.5–8 mm longa, 1–2 mm lata, tridentata, dorso glandulosa et puberula; stylus 4–6 mm longus, rami 0.7–1 mm longi glabri; flores disci ca. 30–56 submasculi; corolla tubulosa, 5–6 mm longa flava, puberula et glandulo-punctata, tubus ca. 1.5 mm longus glanduloso-pilosus 5-lobatus, lobis deltoideis pilosis ca. 0.8 mm longis; antherae nigrescentes 1.5–2 mm longae, appendice antherarum ovato; stylus brevis 2-lobatus, apice piloso, ca. 6 mm longus. Cypselae nigrae obovoideae striatae glabrae, ca. 3 mm longae et 2–2.5 mm latae. Pappus nullus.

Erect herb to 3 m tall; stems terete, canaliculate, hollow, pilose. Leaves opposite, petiolate, membranaceous, triplinerved, adaxial surface puberulous chiefly on veins, abaxial surface puberulent to pilose chiefly on veins, glandular-punctate; upper leaves ovate, dentate, the petiole winged lobate; lower leaves triangular, lobate dentate, acuminate, the base truncate, abruptly tapering to the lower winged portion, to 35 cm long and 26 cm wide. Inflorescence terminal and also axillary from distal nodes, cymose, 2–4-headed; peduncles ca. 1–7 cm long, glandular-pilose. Involucral bracts in 2–3 rows, dimorphic: outer 5, spreading, foliaceous, ovate to lanceolate, apically acute to acuminate, 6–12 mm long, 3–7 mm wide, with ca. 5–14 parallel nerves, pilose, the margin glandular-pilose; inner 17–26, concave, enfolding the ray cypselas, ovate to lanceolate, abaxially glandular and densely pilose, 5–9 mm long, 2–3 mm wide, acuminate to long-acuminate; receptacle flattened, paleaceous, the paleae membranaceous, lanceolate, 5–6 mm long, 1–2 mm wide, acuminate, the margin pilose above. Ray florets 17–26 in 1–2 series, carpellate: corolla 7–10 mm long, yellow, the tube 1.5–2.5 mm long, glandular-pilose, the ligule 5–8-nerved, 5.5–8 mm long, 1–2 mm wide, 3-dentate, abaxially glandular-punctate and puberulent; style 4–6 mm long, branches 0.7–1 mm long, glabrous; disk florets 30–56, functionally male; corolla tubular, 5–6 mm long, yellow, tube 1.5 mm long, glandular-pilose, throat 3–4 mm long, glandular-punctate and puberulent, lobes 5, triangular, pilose, 0.8 mm long; anthers black, 1.5–2 mm long, apical appendage ovate; style shortly 2-lobed and pilose apically, 6 mm long. Cypselas black, compressed-obovoid, striate, glabrous, ca. 3 mm long and 2–2.5 mm wide. Pappus absent.

Paratypes: Brazil. Rio Grande do Sul: Cambará do Sul, Ouro Verde, ca. 2 km da Celulose Cambará, 31 Jan 2003, Mondin 2920 (HASU, ICN); Cambará do Sul, ca. 1 km de Ouro Verde, 31 Jan 2003, Mondin 2921 (HASU).

Distribution and ecology: This species is known only from wet areas of the Araucaria Forest in the region of Campos de Cima da Serra, Cambará do Sul, Rio Grande do Sul, Brazil. It occurs at about 1000 m in elevation and has been collected in flower in January and February.

For the distinction of the species see the discussion under *S. riograndensis*.

Acknowledgements

I wish to express my sincere gratitude to Ilsi I. Boldrini for orientation, stimulus and suggestions, to Tarciso Filgueiras for correcting the Latin diagnoses, to Micheline Vergara for providing the drawings and to Alessandra Iob for collecting.

References

Bremer, K. 1994. *Asteraceae: Cladistics & Classification.* Timber Press, Portland, Oregon.

Robinson, H. 1978. Studies in the Heliantheae (Asteraceae), XII: re-establishment of the genus *Smallanthus*. *Phytologia* 39: 47–53.

Wells, J. R. 1965. A taxonomic study of *Polymnia* (Compositae). *Brittonia* 17: 144–159.

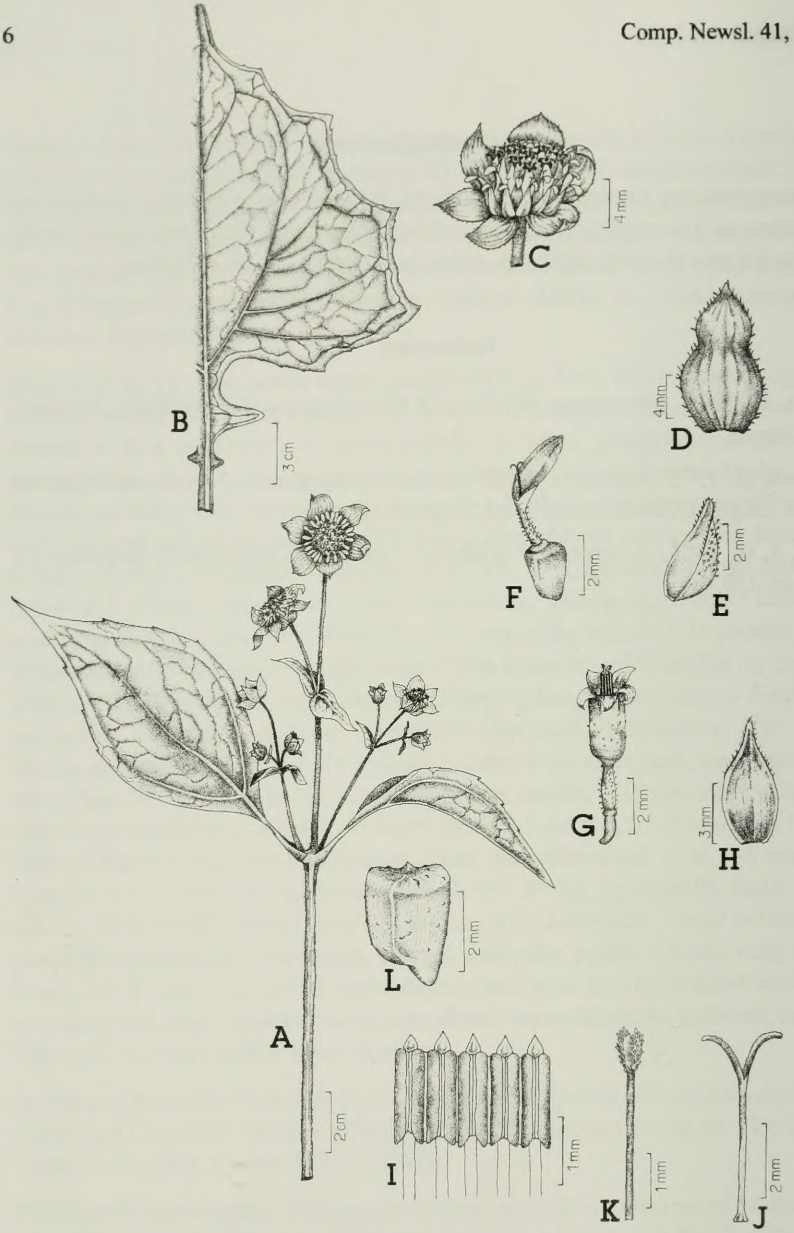


Fig. 1. *Smallanthus riograndensis* C. Mondin. **A**. Flowering branch. **B**. Lower leaf. **C**. Head. **D**. Outer involucral bract. **E**. Inner involucral bract. **F**. Ray floret. **G**. Disk floret. **H**. Palea. **I**. Anther cylinder (and filaments) opened longitudinally. **J**. Ray floret style. **K**. Disk floret style. **L**. Cypsela. (From Mondin & Iob 2653).

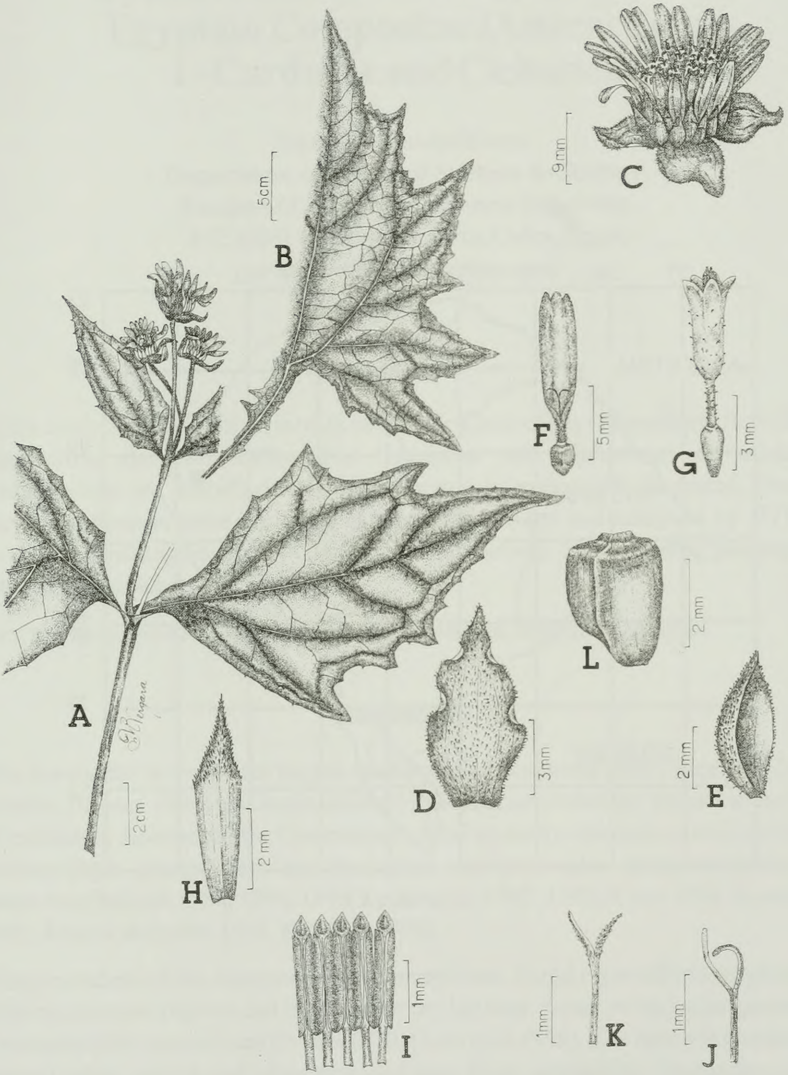


Fig. 2. *Smallanthus araucariophilus* C. Mondin. **A**. Flowering branch. **B**. Lower leaf. **C**. Head. **D**. Outer involucral bract. **E**. Inner involucral bract. **F**. Ray floret. **G**. Disk floret. **H**. Palea. **I**. Anther cylinder (and filaments) opened longitudinally. **J**. Ray floret style. **K**. Disk floret style. **L**. Cypsela. (From Mondin 2920).

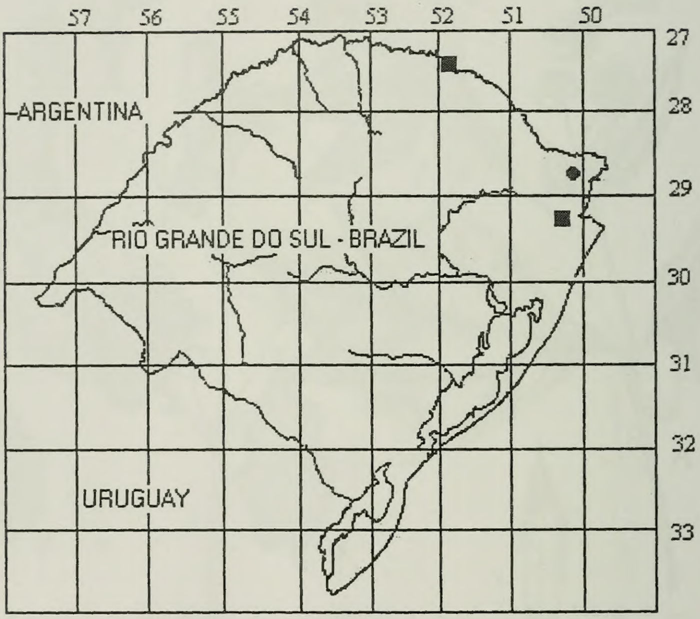


Fig. 3. Distribution map. Square, *Smallanthus riograndensis* C. MONDIN. Dot, *Smallanthus araucariophilus* C. MONDIN.

Cytotaxonomical investigations of the Egyptian Compositae (Asteraceae): I - Cardueae and Cichorieae

EHAB ABDELRAZIK KAMEL
Department of Biological Sciences & Geology,
Faculty of Education, Ain Shams University,
P.C.11341 (Heliopolis), Roxy, Cairo, Egypt
e-mail: ehabk63@yahoo.com

Abstract

In this study, karyotype criteria of 30 taxa of the Compositae (Asteraceae) from Egypt representing the two main tribes (Cardueae and Cichorieae) of subfamily Cichorioideae are described and the taxonomic inferences are discussed. Detailed karyotype features were attributed as characters, coded and analysed by NTSYS-pc-program package using UPGMA clustering method. The produced phenograms were also discussed.

Key words: Egyptian Asteraceae, karyotype studies, numerical analysis.

Introduction

The Asteraceae is one of the largest families of angiosperms (1535 genera & 23000 species; BREMER 1994) and is considered by most taxonomists the highest in the scale of evolution. Asteraceae (or Compositae) form an easily recognized and obviously monophyletic group; both morphological and molecular synapomorphies are numerous (BREMER 1987, 1994, 1996, JANSEN et al. 1991, 1992, KARIS 1993, KARIS et al. 1992, KEELEY & JANSEN 1991, KIM et al. 1992).

Many members of the Asteraceae are cosmopolitan, found especially in temperate or tropical montane regions and open and/or dry habitats. Some of the major genera are *Centaurea* (600 species) and *Cirsium* (270) (JUDD et al. 1999). The family is divided into several tribes, which are often arranged into three subfamilies (Barnadesioideae, Cichorioideae and Asteroideae; BREMER 1994).

In the flora of Egypt, the Asteraceae are well represented with 92 genera and 226 species, with most genera within the Cardueae (17) and the Cichorieae (20). The most speciose genera are *Centaurea* (about 15 species) and *Launaea* (about 11 species) (EL-HADIDI & FAYED 1995).

The subfamily Cichorioideae is a paraphyletic group and characterized by style branches with the inner surface stigmatic. Their flowerheads are usually discoid, except in the distinct tribe Lactuceae, which has ligulate heads. Both resin canals and laticifers occur within the subfamily and the latex system is especially well developed in Lactuceae. The Lactuceae are phenetically distinct and have sometimes been placed in their own subfamily (CRONQUIST 1981, BREMER 1996).

Generic delimitation within the Cardueae (= Cynareae) is problematic. It is quite possible that the larger genera are paraphyletic with some small derivative genera excluded. The distinction between the two large genera *Carduus* and *Cirsium* is dubious, resting on the technical difference between scabrid-barbellate and plumose pappus bristles, respectively. Generic and subtribal classifications within the Cardueae and especially within the Carduinae need a detailed study from a cladistic perspective. The Cardueae are a fairly sizable group with 83 genera and 2500 species (JUDD et al. 1999). There are several large genera, each with hundreds of species (e.g. *Centaurea*). The Cardueae comprise four subtribes, viz. two large and about equal-sized subtribes, the Carduinae and the Centaureinae, and the two smaller Carlininae and Echinopsidinae (BREMER 1994).

The Lactuceae (= Cichorieae) are perhaps the best known and most easily recognized tribe of the family. Lettuce (*Lactuca sativa* L.) and endive (*Cichorium endivia* L.) are familiar members of the tribe. The ligulate capitula and the milky latex immediately set the Lactuceae apart from almost all other Asteraceae. The Lactuceae are also known as tribe Cichorieae. They have often been considered a subfamily or even a separate family, but they are now universally considered a tribe well nested within the Asteraceae, with distinctive autapomorphic florets. The Cichorieae comprise 98 genera and more than 1550 species (JUDD et al. 1999). Among the largest genera is *Crepis* (200 species). The classification of the Cichorieae into genera and subtribes is in a much better state than in most other tribes of the family. STEBBINS (1953) presented a subtribal classification of the Cichorieae, later informally modified by JEFFREY (1966). He classified the tribe into eight subtribes as follows: Scolyminae, Cichoriinae, Microseridinae, Stephanomeriinae, Dendroseridinae, Scorzonerinae, Leontondontinae and Crepidinae (cf. BREMER 1994).

Chromosome numbers are fairly well surveyed in the Lactuceae (STEBBINS et al. 1953, TOMB et al. 1978). There is a series of base numbers ranging from x = 10 in *Scolymus* to x = 4 in *Hedypnois*. The base numbers were coded as six unordered character states. The most common number is x = 9. A gradual reduction in base number thus was not assumed initially but comes out as a parsimonious solution in many of the cladograms. The base numbers x = 6 and x = 7 were lumped into one character state, since it is unclear whether some genera (*Leontodon*) have x = 6 or x = 7 (STEBBINS 1953).

Chromosomes have been considered as sources of valid taxonomic criteria (Moore 1978, Jackson 1984). The karyotype data also appear to be of taxonomic value in providing a logical basis for the redistribution of genera in tribes. Karyotype studies were principally based on the idea that symmetrical karyotypes are more primitive than asymmetrical ones; longer chromosomes more primitive than shorter ones; median centromeres with chromosome arms of equal length were more primitive than chromosomes with arms of unequal length; low basic numbers had given rise to higher ones. These features are based on the comparison between karyotypes of known relative antiquity, as determined through classical taxonomy (Sharma 1990).

In the present work, chromosome numbers and detailed karyotype features of 30 taxa of Egyptian Asteraceae representing two tribes, Cardueae (8 genera) and Cichorieae (11 genera) were studied. The produced features of the karyotypes were coded and analysed by the NTSYS-pc program package, using UPGMA cluster method (Rohlf 2000). The phenograms produced are discussed in the light of the current systems of classification (Bremer 1994, 1996).

Materials and Methods

Materials of the 30 taxa were collected from various habitats in Egypt. Voucher specimens are deposited at the herbarium of Biological Sciences and Geology Department, Faculty of Education, Ain Shams University, Roxy, Cairo, Egypt.

1. Cytological Studies

Cytological preparations were carried out on root tips obtained from seeds germinated on sterile moist filter paper in Petri dishes at 25° C. Roots were pretreated with 0.05 % colchicine solution for 2–3 hrs. and fixed in Carnoy for 24 hrs. and stored in 70 % ethanol at 4° C. Cytological preparations were made using the Feulgen squash method. The well-spread c-metaphase chromosomes were photographed from temporary preparations at magnifications of 2000x. Slides of the original karyotypes are also preserved in the Laboratory of Cytogenetics of the same department.

A karyogram for each taxon was constructed by arranging the chromosomes in homologous pairs by order of their length and arm ratio as measured from the photographic prints. The number of chromosome types was determined as described by Levan et al. (1964). Measurements of chromosome length were taken on the same photographs of the karyogram.

The variation in chromosome length (MCL) and chromosome arm ratio (MAR) within the karyotype have been estimated by calculating the standard error (SE) of these parameters. Karyotype asymmetry deduced from the ratio between the short arms of the chromosomes and their total length was expressed as total form percent (TF %) as proposed by HUZIWARA (1962). Karyotype asymmetry expressed by the ratio between chromosome arms has been also estimated as the intrachromosomal asymmetry index (A_1) as suggested by ROMERO ZARCO (1986).

The value of A_1 is considered to be close to zero if all chromosomes are metacentric and near to one if all chromosomes are telocentric. Karyotype asymmetry due to the ratio between size of different chromosomes has been also estimated as the interchromosomal asymmetry index (A_2) using PEARSON's dispersion coefficient, that is the ratio between the standard deviation and the mean chromosome length (ROMERO ZARCO 1986).

The existence of previous chromosome counts for the studied taxa has been verified in the indexes of plant chromosome numbers by FEDOROV (1969), GOLDBLATT (1981, 1984, 1985, 1988) and GOLDBLATT & JOHNSON (1990, 1991, 1994, 1996, 1998).

2. Numerical Analysis

For the data analysis, the total number of the recorded attributes (29) in all taxa were scored, combined together in two sets of data and coded for creating the data matrix of computation: (a) Tribe Cardueae and (b) Tribe Cichorieae. The presence or absence of each of the 29 different attributes was treated as a binary character in a data matrix, i.e. coded 1 and 0 respectively (Table 2). The relationships between the studied species, expressed by average taxonomic distance (dissimilarity), have been demonstrated as phenograms, based on the analysis of the recorded characters using the NTSYS program package for IBM-pc as described by ROHLF (2000).

Results

1. Cytological Observations

A. Tribe Cardueae

This tribe is represented in the study by eight genera and 11 species (Table 1, Figs. 1 & 2). Chromosome counts and karyotype description of *Carduus pycnocephalus* were previously reported by KAMEL (1999), whereas the karyotype analyses for both *Centaurea glomerata* and *Notobasis syriaca* were previously reported by KAMEL (2001). Basic chromosome numbers vary between $x = 8$ in *Amberboa* and *Centaurea aegyptiaca* to $x = 17$ in the three genera *Notobasis*, *Onopordum* and *Silybum*. In *Carduus pycnocephalus*, $x = 9$ is recorded, whereas in *Cnicus* and *Echinops* $x = 11$ and $x = 14$ are observed (respectively). Three species of the genus *Centaurea* (*C. alexandrina*, *C. calcitrapa* and *C. glomerata*) were found to have $x = 10$.

The highest MCL among the eleven species of Cardueae was found in *Centaurea calcitrapa* (2.38 ± 0.21 μm), whereas the shortest was observed in *Silybum marianum*

(1.14 ± 0.04 µm). The highest MAR value (1.56 ± 0.09) was recorded in *Centaurea calcitrapa*, whereas the lowest (1.12 ± 0.03) was found in *Onopordum alexandrinum*. The low MAR recorded for the species of the tribe is correlated with high values of the TF % (Table 1), indicating a high degree of karyotype symmetry. However, the A_1 and A_2 values indicate some degree of karyotype asymmetry in two species (*Centaurea aegyptiaca* and *C. calcitrapa*). The A_1 value ranges between 0.10 in *Onopordum alexandrinum* to 0.33 in *Centaurea calcitrapa*, whereas the highest A_2 (0.31) value was found in *Carduus pycnocephalus* and the lowest (0.12) was observed in both *Centaurea alexandrina* and *Notobasis syriaca* (Table 1). *Centaurea calcitrapa* was found to have SAT in its chromosome.

B. Tribe Cichorieae

The chromosome numbers and karyotype description are shown for 19 species of the tribe Cichorieae (Table 1 and Figs. 2–5). The karyotype analyses of the three genera *Garhadiolus*, *Picris* and *Thrincia* were previously reported by Kamel (1999).

Somatic chromosome number varied between a diploid of $2n = 8$, recorded in the genus *Thrincia,* to a tetraploid of $2n = 32$, recorded in two species of the genus *Launaea* (*L. capitata* and *L. cassiniana*) and in the two species of the genus *Sonchus* (*S. macrocarpus* and *S. oleraceus*). The basic chromosome numbers recorded within the studied species were $x = 4, 5, 6, 8$, and 9. The basic number of $x = 4$ was observed in the genus *Thrincia* only, whereas $x = 5$ was recorded in the two genera *Picris* and *Urospermum*. On the other hand, $x = 6$ was recorded in the genus *Garhadiolus*. The basic number $x = 8$ was recorded in 11 species, whereas $x = 9$ was recorded in four species.

The highest MCL among the studied species of Cichorieae was found in *Garhadiolus* (2.99 ± 0.23 µm), whereas the shortest was observed in *Sonchus oleraceus* (1.30 ± 0.08 µm). The highest MAR value (2.07) was recorded in *Garhadiolus*, whereas the lowest (1.11) was found in the two species of the genus *Sonchus*. Of the studied species, 14 species were found to have TF % above 40 % indicating a high degree of karyotype symmetry. The five species *Cichorium endivia*, *Garhadiolus hedypnois*, *Lactuca sativa*, *Picris damascena* and *Thrincia tripolitana* were found to have asymmetric karyotypes as indicated by the values of A_1 and A_2. Both *Crepis* and *Launaea nudicaulis* were found to have SAT within its chromosomes.

2. Numerical Observations

A. The phenogram of tribe Cardueae

The phenogram obtained (Fig. 6) shows that the examined taxa have a total genetic (taxonomic) distance of about 1.69. At this level, two species of the genus *Centaurea* (*C. aegyptiaca* –3 and *C. calcitrapa* –5) were split off from the other taxa and then distinguished from each other at the level of about 1.33. At the levels 1.47 and 1.35, the two species *Carduus pycnocephalus* (2) and *Echinops spinosissimus* (8) were split off from the remaining taxa, respectively.

The remaining seven taxa were further split off into two groups at the level of about 1.20. The first group includes three taxa (*Centaurea alexandrina* –4, *Cnicus benedictus* –7 and *Notobasis syriaca* –9), while the second one comprised four taxa (*Amberboa lippii* –1, *Centaurea glomerata* –6, *Onopordum alexandrinum* –10 and *Silybum marianum* –11).

Within the first group, *Notobasis syriaca* (9) was split off from the other taxa at the level of about 1.03. On the other hand, the remaining two taxa (*Centaurea alexandrina* –4 and *Cnicus benedictus* –7) were distinguished from each other at the level of about 0.84. The second group was subdivided at the level of 1.14 into two subgroups. Each of them includes two taxa. The two taxa of the first subgroup (*Onopordum alexandrinum* –10 and *Silybum marianum* –11) were distinguished from each other at the level of about 0.83, whereas, those of the second subgroup (*Amberboa lippii* –1 and *Centaurea glomerata* –6) were distinguished from each other at the level of about 0.71.

B. The phenogram of tribe Cichorieae

Figure 7 demonstrates the phenogram obtained by the analyses of the studied taxa across the data produced through the karyological attributes. As shown in this phenogram, the studied taxa have a total genetic distance of about 1.75. At this level, the studied taxa were split off into two categories. The first category includes only three taxa (*Garhadiolus hedypnois* –14, *Picris damascena* –24 and *Thrincia tripolitana* –29), while the second one comprises the remaining taxa (16 taxa).

Within the first category, *Thrincia tripolitana* (29) was separated from the other two taxa at the level of about 1.40, while *Garhadiolus hedypnois* (14) and *Picris damascena* (24) were distinguished from each other at the level of about 1.13.

Within the second category, *Cichorium endivia* (12), the two species of the genus *Lactuca* (*L. sativa* –16 and *L. serriola* –17) and *Launaea nudicaulis* (21) were grouped together in a small group at the level of about 1.55. Within this group, *Lactuca serriola* (17) and *Launaea nudicaulis* (21) were split off at the level of 1.43 and then distinguished from each other at the level of 0.77. At the level 1.43, the two taxa *Cichorium endivia* (12) and *Lactuca sativa* (16) were further split off.

Of the remaining taxa, *Crepis radicata* (13) was split off at the level of 1.37. Also, *Urospermum picroides* (30) was split off from the rest taxa at the level of 1.25. At the level of 1.00, the two taxa *Hyoseris lucida* (15) and *Sonchus macrocarpus* (27) were split off and then distinguished from each other at 0.82 level. On the other hand, at the level of 0.82, another two taxa were split off (*Launaea tenuiloba* –23 and *Reichardia picroides* –25) and then distinguished from each other at 0.40 level. At the level of 0.75

Sonchus oleraceus (28) was split off from the remaining taxa.

At the level of 0.50, the remaining taxa were divided into two groups, the first one including two species of the genus *Launaea* (*L. capitata* –18 and *L. cassiniana* –19), while the second one comprised three; viz. another two species of *Launaea* (*L. mucronata* –20 and *L. resedifolia* –22) and *Reichardia tingitana* (26).

Discussion

The phenogram produced from the numerical analysis of the studied taxa of tribe Cardueae (Fig. 6) based on 29 karyological characters recorded some relationships within these members.

Centaurea aegyptiaca (3) and *C. calcitrapa* (5) at 1.33 level due to their possessing the highest MCL (2.07 and 2.38 µm).

The separation of *Carduus pycnocephalus* (2) at 1.47 level and *Echinops spinosissimus* (8) at 1.35 level due to their possessing the basic chromosome number of $x = 9$ and $x = 14$, respectively.

The clustering of the three taxa, *Notobasis syriaca* (9), *Cnicus benedictus* (7) and *Centaurea alexandrina* (4), at the level of 1.03 due to their possessing the same TF % (42.94, 42.47 and 42.67 %, respectively).

The clustering of the four taxa, *Onopordum alexandrinum* (10), *Silybum marianum* (11), *Amberboa lippii* (1) and *Centaurea glomerata* (6) at the level of 1.14 due to their possessing the highest TF % (47.14, 46.32, 45.52 and 45.77 %, respectively).

On the other hand, the separation of *Onopordum alexandrinum* (10) and *Silybum marianum* (11) at the level of 0.83 due to their possessing the basic chromosome number of $x = 17$ and their karyotype formula comprising M and m types of chromosomes.

Both *Amberboa lippii* (1) and *Centaurea glomerata* (6) were grouped at the level of 0.71 due to their possessing the same TF % (about 45 %), tetraploid somatic chromosome number ($2n = 32$ and $2n = 48$, respectively) and the presence of metacentric (m) type of chromosomes.

As to the members of tribe Cichorieae, the following relationships were recorded from the numerical analysis of the karyological characters (Fig. 7). The clustering of the three taxa, *Thrincia tripolitana* (29), *Garhadiolus hedypnois* (14) and *Picris damascena* (24) at the level of 1.40 due to their possessing low basic chromosome number of $x = 4$, 6 and 5 (respectively) and longer chromosomes as observed from the values of MCL (1.90, 2.99 and 2.67 µm, respectively).

The clustering of the four taxa *Cichorium endivia* (12), *Lactuca sativa* (16), *Lactuca serriola* (17) and *Launaea nudicaulis* (21) at the level of 1.43 due to their possessing the basic chromosome number of x = 9 within the karyotypes. *Cichorium endivia* (12) and *Lactuca sativa* (16) due to the presence of the low values of TF % (39.88 and 37.69 %), whereas *Lactuca serriola* (17) and *Launaea nudicaulis* (21) at 0.77 level due to the presence of the high values of TF % (42.62 and 42.65 %).

The separation of *Crepis radicata* (13) at 1.37 level due to the possessing of longer chromosomes which characterized its karyotype (MCL = 2.89 ± 0.16 μm), and the presence of the SAT, the separation of *Urospermum picroides* (30) at the level of 1.25 due to the presence of x = 5 with shorter chromosomes (MCL = 1.56 ± 0.06 μm).

Hyoseris lucida (15) and *Sonchus macrocarpus* (27) at 0.82 level due to their possessing similar karyotype symmetry as indicated by TF % values (47.27 and 47.42 %), A_1 (0.10 and 0.09) and A_2 (0.13 and 0.15) (Table 1).

Launaea tenuiloba (23) and *Reichardia picroides* (25) at the level of 0.40 due to their possessing similar MCL (1.72 and 1.74 μm), MAR (1.31) and TF % (43.36 and 43.58 %).

The separation of *Sonchus oleraceus* (28) from the remaining taxa at the level of 0.75 due to the possessing of the shortest chromosomes (MCL = 1.30 ± 0.08 μm) which characterized its karyotype.

The clustering of the five taxa *Launaea capitata* (18), *L. cassiniana* (19), *L. mucronata* (20), *L. resedifolia* (22) and *Reichardia tingitana* (26) at the level of 0.50 due to their possessing the same basic chromosome number (x = 8), high karyotype symmetry (TF % = 46.15, 44.24, 45.14, 44.81 and 45.77 %, respectively) and karyotype formula of metacentric chromosomes (m).

Most of the studied species were found to have metacentric or submetacentric chromosomes indicating that most karyotypes of the Cardueae and Cichorieae are symmetric. It is also indicated that the members of both tribes are primitive.

Most of the karyotypes studied were found to be symmetric (23 species were found to have TF % above 40 %). The value of the TF % for the studied species thus supported previous observations that karyotype in the Asteraceae is symmetric. Longer chromosomes are associated with karyotype asymmetry as revealed by MAR, TF% and A_1 values in both tribes Cardueae and Cichorieae.

Acknowledgement

The author is grateful to Prof. Dr. BERTIL NORDENSTAM, Department of Phanerogamic Botany, Swedish Museum of Natural History, Stockholm, Sweden for revising the manuscript and his kind correspondence.

References

Bremer, K. 1987. Tribal interrelationships of the Asteraceae. *Cladistics* 3: 210–253.

Bremer, K. 1994. *Asteraceae. Cladistics and Classification.* Timber Press, Portland, Oregon.

Bremer, K. 1996. Major clades and grades of the Asteraceae. *In:* Hind, D. J. N. & H. J. Beentje (eds.), *Compositae: Systematics.* Proceedings of the International Compositae Conference, Kew, 1–7. Royal Botanic Gardens, Kew.

Cronquist, A. 1981. *An integrated system of classification of flowering plants.* Columbia University Press, New York.

El-Hadidi, M. N. & A. A. Fayed (eds.) 1995. Materials for excursion flora of Egypt (EFE). *Taeckholmia* 15: 74–75. Cairo Univ. Herbarium. Giza, Egypt.

Fedorov, A. A. 1969. *Chromosome numbers of flowering plants.* Academy of Sciences of USSR, Leningrad.

Goldblatt, P. 1981. Index to plant chromosome numbers 1975–1978. *Monogr. Syst. Bot. Missouri Bot. Gard.* 5.

Goldblatt, P. 1984. Index to plant chromosome numbers 1979–1981. *Monogr. Syst. Bot. Missouri Bot. Gard.* 8.

Goldblatt, P. 1985. Index to plant chromosome numbers 1982–1983. *Monogr. Syst. Bot. Missouri Bot. Gard.* 13.

Goldblatt, P. 1988. Index to plant chromosome numbers 1984–1985. *Monogr. Syst. Bot. Missouri Bot. Gard.* 23.

Godlblatt, P. & D. E. Johnson 1990. Index to plant chromosome numbers 1986–1987. *Monogr. Syst. Bot. Missouri Bot. Gard.* 30.

Goldblatt, P. & D. E. Johnson 1991. Index to plant chromosome numbers 1988–1989. *Monogr. Syst. Bot. Missouri Bot. Gard.* 40.

Goldblatt, P. & D. E. Johnson 1994. Index to plant chromosome numbers 1990–1991. *Monogr. Syst. Bot. Missouri Bot. Gard.* 51.

Goldblatt P. & D. E. Johnson 1996. Index to plant chromosome numbers 1992–1993. *Monogr. Syst. Bot. Missouri Bot. Gard. 58.*

Goldblatt, P. & D. E. Johnson 1998. Index to plant chromosome numbers 1994–1995. *Monogr. Syst. Bot. Missouri Bot. Gard.* 60.

Huziwara, Y. 1962. Karyotype analysis is some genera of Compositae VIII. Further studies on the chromosomes of *Aster. Amer. J. Bot.* 49: 116–119.

Jackson, R. C. 1984. Chromosome pairing in species and hybrids. *In*: W.F. Grant (ed.), *Plant Biosystematics*. Academic Press, Toronto.

Jansen, R. K., Michaels, H. J. & J. D. Palmer 1991. Phylogeny and character evolution in the Asteraceae based on chloroplast DNA restriction site mapping. *Syst. Bot.* 16: 98–115.

Jansen, R. K., Michaels, H. J., Wallace, R. S., Kim, K.-J., Keeley, S. C., Watson, L. E. & J. D. Palmer 1992. Chloroplast DNA variation in the Asteraceae: Phylogenetic and evolutionary implications. *In:* Soltis, P. S., Soltis, D. E. & J. J. Doyle (eds.), *Molecular Systematics of Plants*, pp. 252–294. Chapman and Hall, New York.

Jeffrey, C. 1966. Notes on Compositae, I: The Cichorieae in East Tropical Africa. *Kew Bulletin* 18: 427–486.

Judd, W. S., Campbell, C. S., Kellogg, E. A. & P. F. Stevens 1999. *Plant Systematics: A phylogenetic approach*. Sinauer Associates, Inc. U.S.A.

Kamel, E. A. 1996. *Studies on some relationships between some taxa in the Asteraceae*. Ph. D. thesis, Ain Shams Univ.,Cairo.

Kamel, E. A. 1999. Karyological studies on some taxa of the Asteraceae in Egypt. *Comp. Newsl.* 33: 1–18.

Kamel, E. A.. 2001. Chromosome counts and karyological studies on six taxa of the Egyptian Asteraceae. *Comp. Newsl.* 36: 81–94.

Karis, P. O. 1993. Morphological phylogenetics of the Asteraceae - Asteroideae, with notes on character evolution. *Plant. Syst. Evol.* 186: 69–93.

Karis, P. O., Källersjö, M. & K. Bremer 1992. Phylogenetic analysis of the Cichorioideae (Asteraceae), with emphasis on the Mutisieae. *Ann. Missouri Bot. Gard.* 79: 416–427.

Keeley, S. C. & R. K. Jansen 1991. Evidence from chloroplast DNA for the recognition of a new tribe, Tarchonantheae and the tribal placement of *Pluchea* (Asteraceae). *Syst. Bot.* 16: 173–181.

Kim, K.-J., Jansen, R. K., Wallace, R. S., Michaels, H. J. & J. D. Palmer 1992. Phylogenetic implications of *rbc*L sequence variation in the Asteraceae. *Ann. Missouri Bot. Gard.* 79: 428–45.

Levan, A., Fredga, K., & A. A. Sandberg 1964. Nomenclature for centromeric position of chromosomes. *Hereditas* 52: 201–220.

Moore, D. M. 1978. The chromosomes and plant taxonomy. *In*: H. E. Street (ed.), *Essays in plant taxonomy*. Acad. Press, London, New York.

Rohlf, F. J. 2000. NTSYS-pc, numerical taxonomy and multivariate analysis system, version 2.1. Exeter Software: Setauket, New York.

Romero Zarco, C. R. 1986. A new method for estimating karyotype asymmetry. *Taxon* 35: 526–530.

Sharma, A. 1990. Taxonomy as related to genetic diversity in plants. *J. Indian Bot. Soc.* 69: 1–3.

Stebbins, G. L., Jenkins, J. A. & M. S. Walters 1953. Chromosomes and phylogeny in the Compositae, tribe Cichorieae. *University of California Publications in Botany* 26: 401–430.

Stebbins, G. L. 1953. A new classification of the tribe Cichorieae , family Compositae. *Madroño* 12: 65–81.

Tomb, A. S., Chambers, K. L., Kyhos, D. W., Powell, A. M. & P. H. Raven 1978. Chromosome numbers in the Compositae XIV: Lactuceae. *American J. Bot.* 65: 717–721.

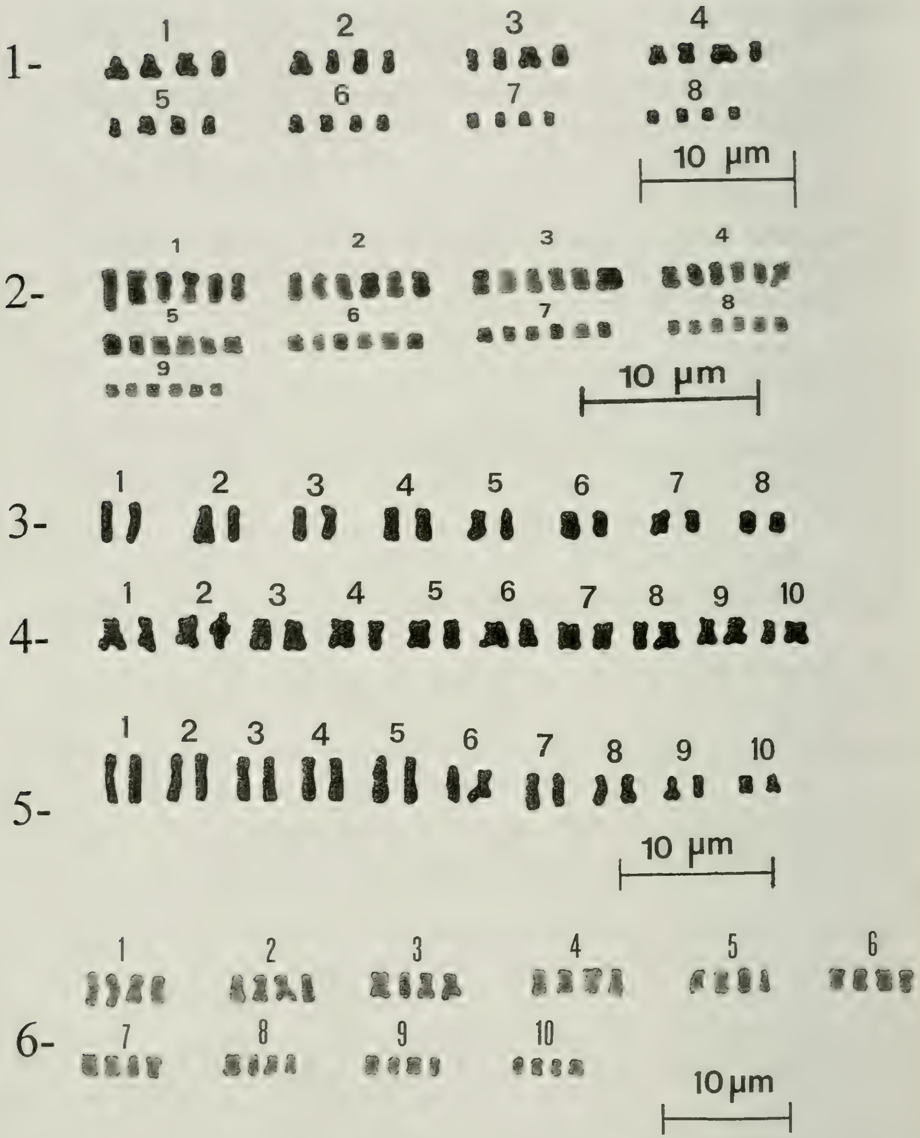


Fig. 1. Karyotype of the studied taxa of tribe Cardueae (Asteraceae)

(1) *Amberboa lippii* (2) *Carduus pycnocephalus*
(3) *Centaurea aegyptiaca* (4) *C. alexandrina*
(5) *C. calcitrapa* (6) *C. glomerata*

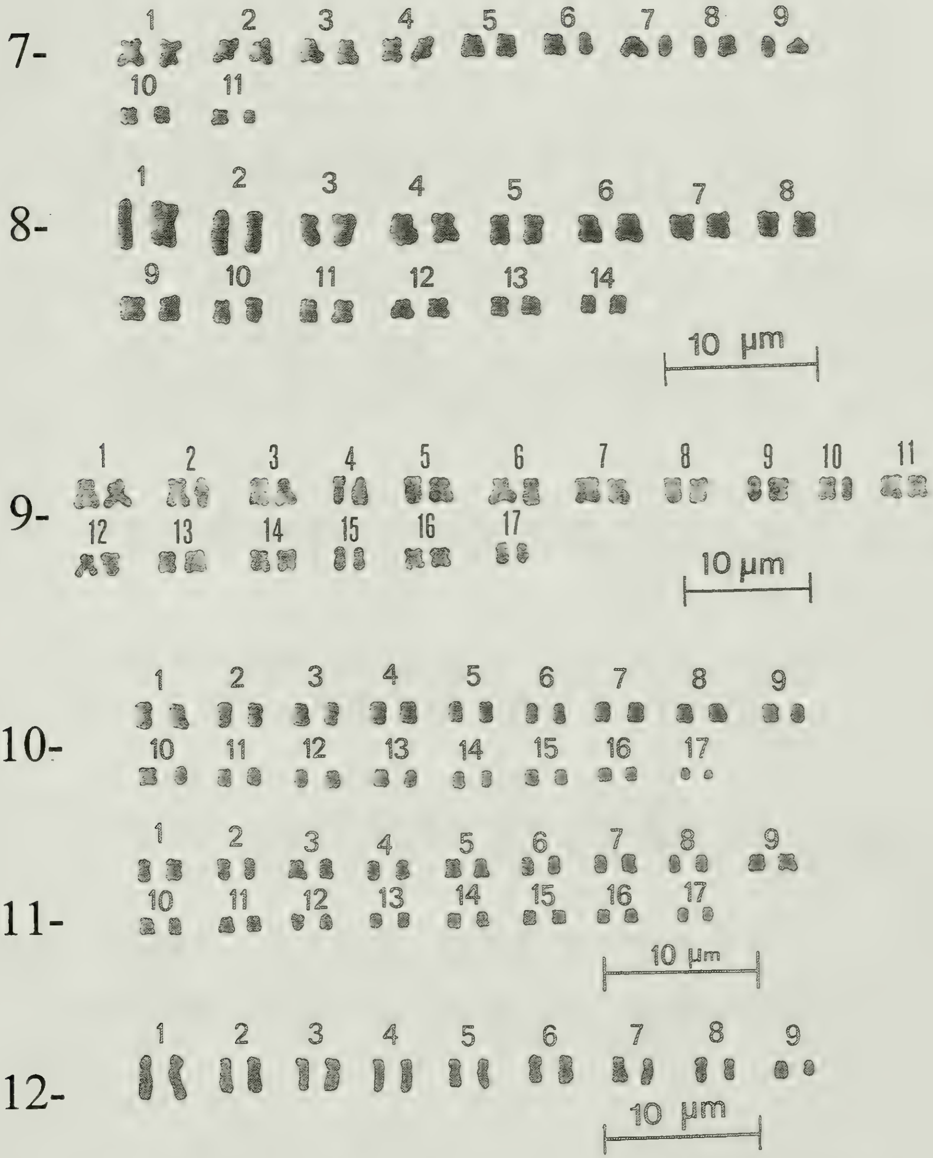


Fig. 2. Karyotype of the studied taxa of tribe Cardueae and Cichorieae (Asteraceae)

(7) *Cnicus benedictus*
(8) *Echinops spinosissimus*
(9) *Notobasis syriaca*
(10) *Onopordum alexandrinum*
(11) *Silybum marianum*
(12) *Cichorium endivia*

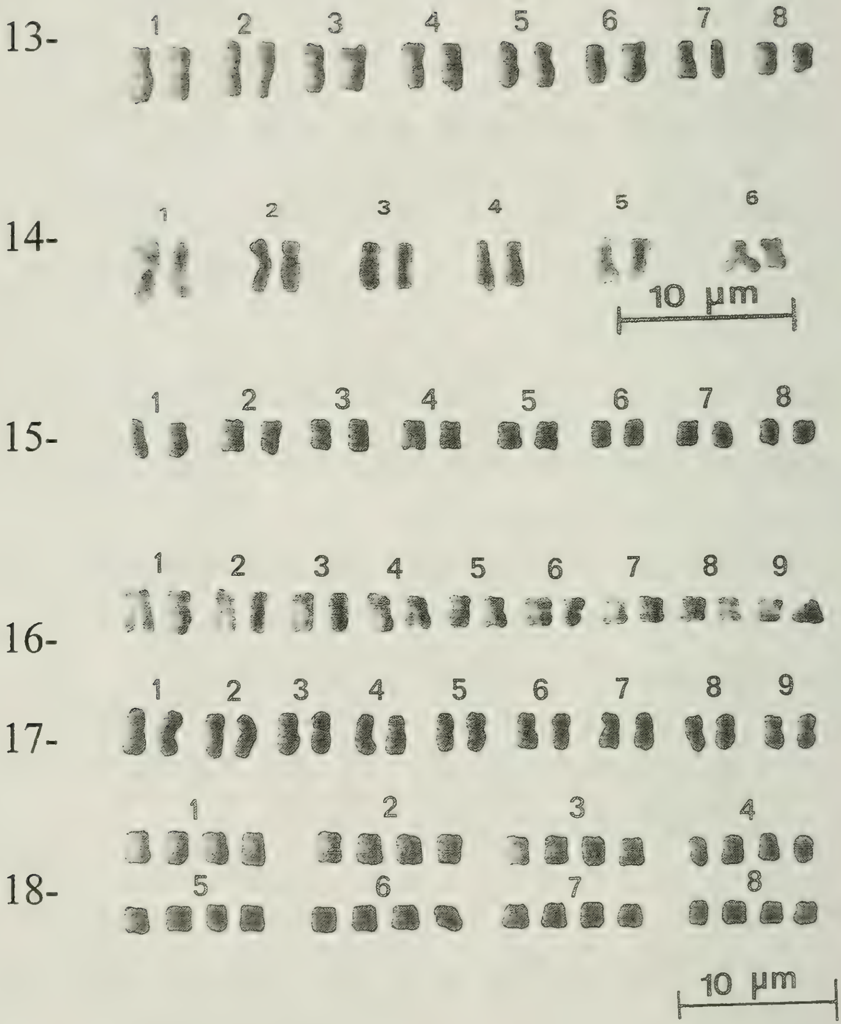


Fig 3. Karyotype of the studied taxa of tribe Cichorieae (Asteraceae)

(13) *Crepis radicata* (14) *Garhadiolus hedypnois*
(15) *Hyoseris lucida* (16) *Lactuca sativa*
(17) *L. serriola* (18) *Launaea capitata*

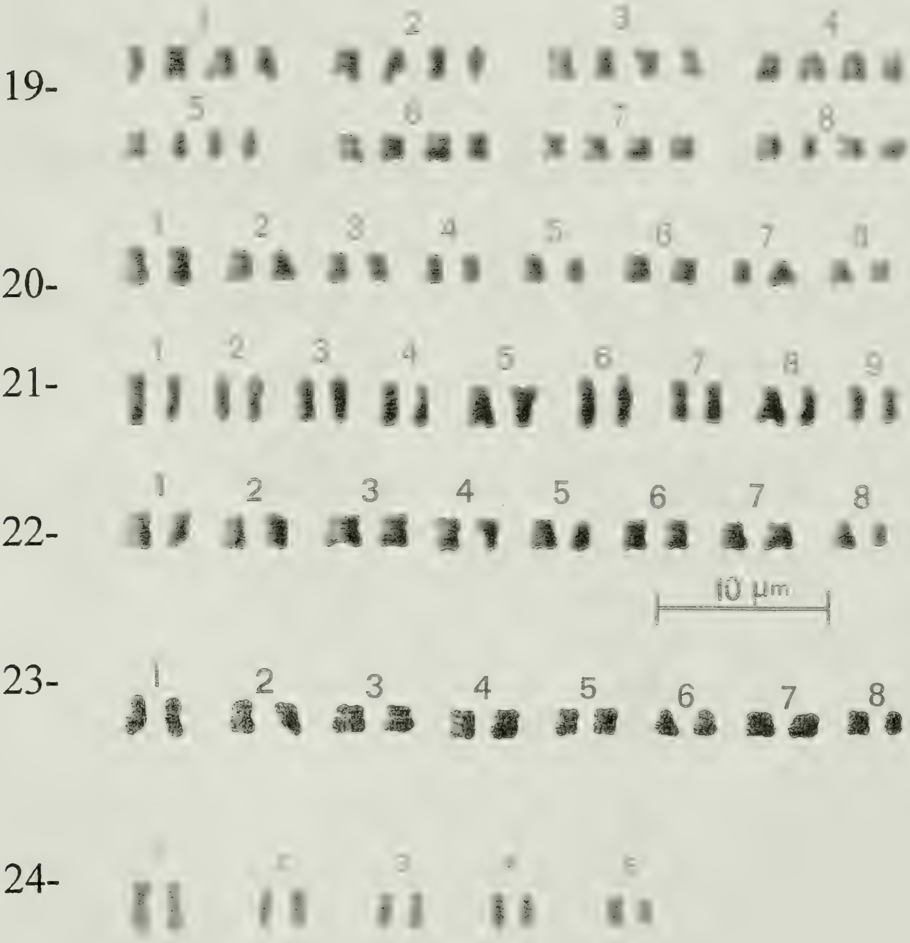


Fig 4. Karyotype of the studied taxa of tribe Cichorieae (Asteraceae)

(19) *Launaea cassiniana* (20) *L. mucronata*
(21) *L. nudicaulis* (22) *L. resedifolia*
(23) *L. tenuiloba* (24) *Picris damascena*

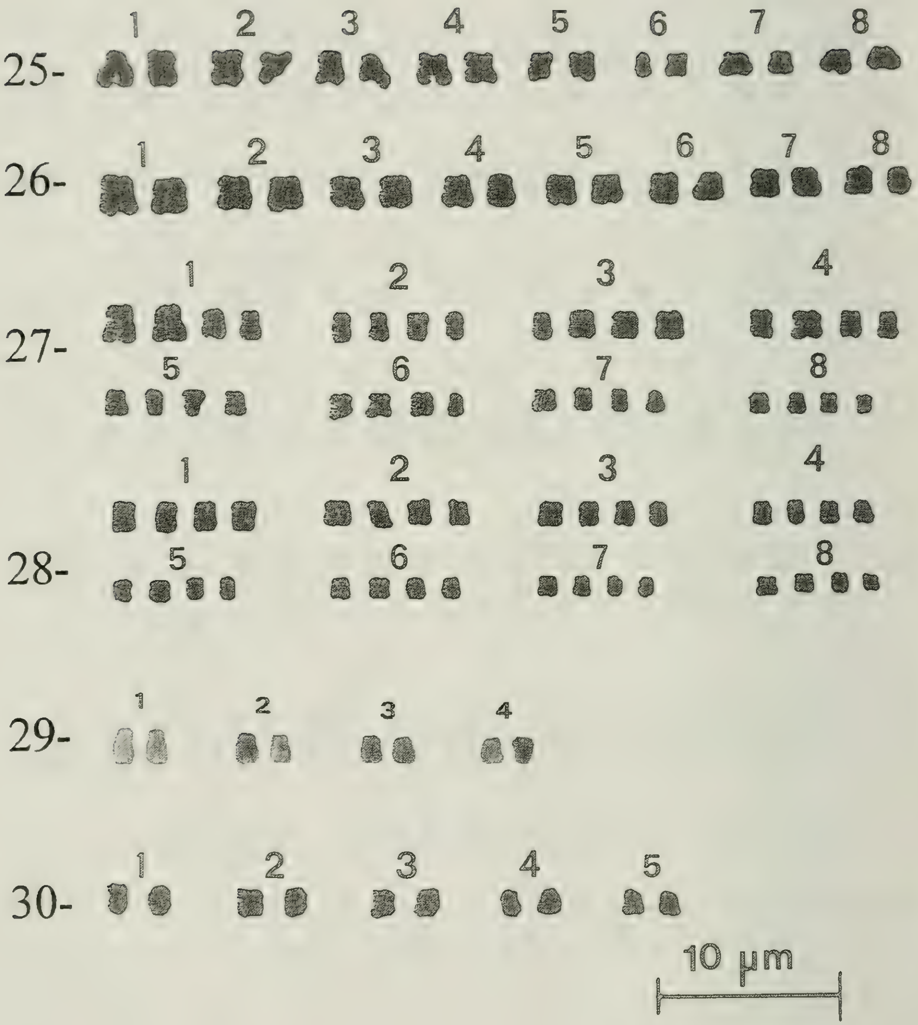


Fig 5. Karyotype of the studied taxa of tribe Cichorieae (Asteraceae)

(25) *Reichardia picroides*
(26) *R. tingitana*
(27) *Sonchus macrocarpus*
(28) *S. oleraceus*
(29) *Thrincia tripolitana*
(30) *Urospermum picroides*

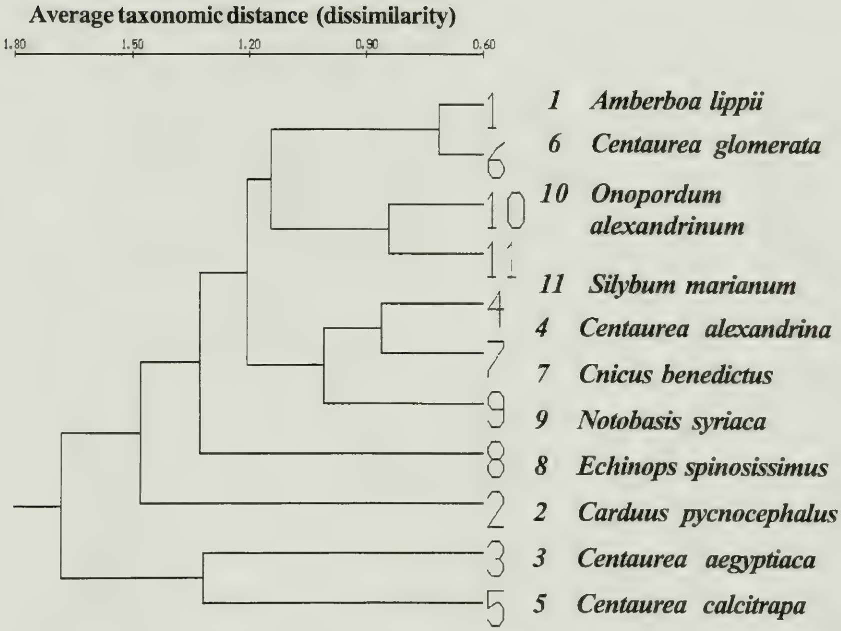


Fig. 6. UPGMA phenogram of the eleven taxa of tribe Cardueae (1-11)

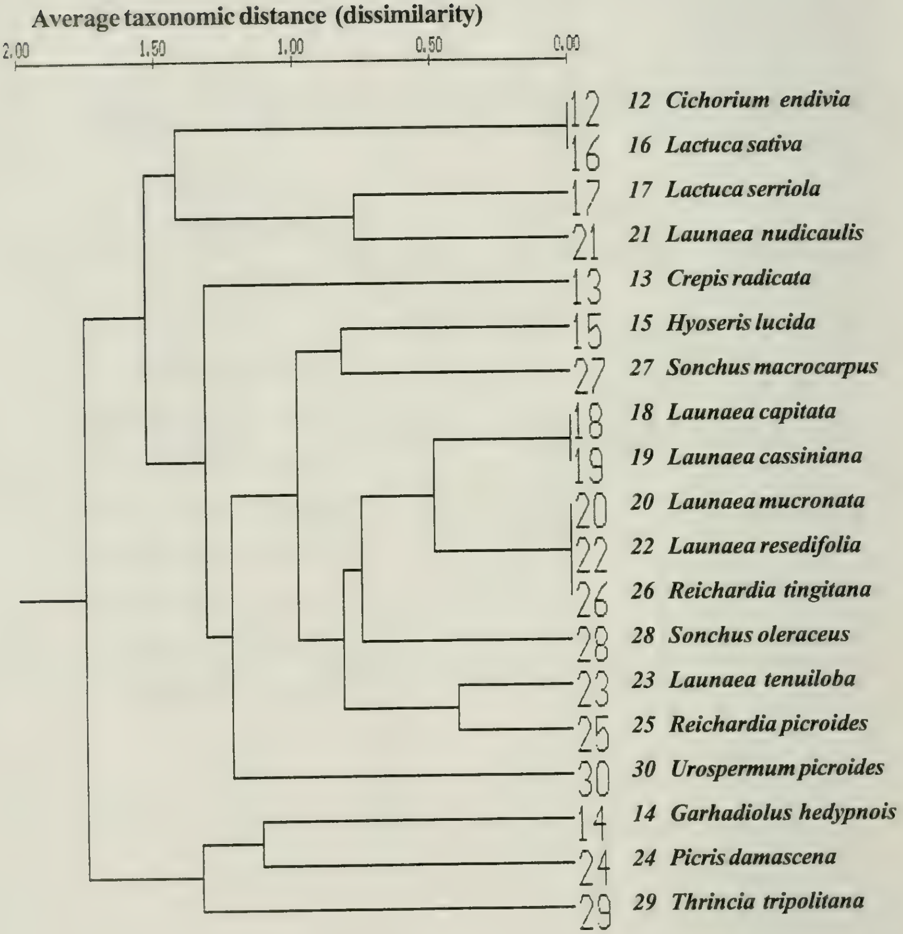


Fig. 7. UPGMA phenogram of the nineteen taxa of tribe Cichorieae (12–30)

Table 1. The cytological features of the studied taxa

No.	Tribe	Taxa	x	2n	MCL ± SE (µm)	MAR ± SE	TF %	A₁	A₂	SAT	Chr. type		
											M	m	sm
1	Cardueae	*Amberboa lippii* (L.) DC.	8	32	1.35 ± 0.09	1.20 ± 0.02	45.52	0.16	0.19	-	-	8	-
2	“	*Carduus pycnocephalus* L.	9	54	1.34 ± 0.14	1.30 ± 0.02	43.64	0.23	0.31	-	-	9	-
3	“	*Centaurea aegyptiaca* L.	8	16	2.07 ± 0.15	1.55 ± 0.21	39.93	0.29	0.21	-	-	7	1
4	“	*C. alexandrina* DEL.	10	20	1.93 ± 0.07	1.35 ± 0.06	42.67	0.25	0.12	-	-	9	1
5	“	*C. calcitrapa* L.	10	20	2.38 ± 0.21	1.56 ± 0.09	38.80	0.33	0.27	+	-	7	3
6	“	*C. glomerata* VAHL	10	40	1.95 ± 0.11	1.19 ± 0.05	45.77	0.15	0.18	-	-	10	-
7	“	*Cnicus benedictus* L.	11	22	1.44 ± 0.08	1.40 ± 0.13	42.47	0.24	0.19	-	-	10	1
8	“	*Echinops spinosissimus* TURRA	14	28	1.86 ± 0.15	1.27 ± 0.05	44.22	0.19	0.30	-	-	13	1
9	“	*Notobasis syriaca* (L.) CASS.	17	34	2.01 ± 0.06	1.35 ± 0.07	42.94	0.23	0.12	-	-	16	1
10	“	*Onopordum alexandrinum* BOISS.	17	34	1.28 ± 0.06	1.12 ± 0.03	47.14	0.10	0.20	-	2	15	-
11	“	*Silybum marianum* (L.) GAERTN.	17	34	1.14 ± 0.04	1.16 ± 0.04	46.32	0.13	0.15	-	3	14	-
12	Cichorieae	*Cichorium endivia* L.	9	18	2.03 ± 0.18	1.49 ± 0.09	39.88	0.31	0.26	-	-	6	3
13	“	*Crepis radicata* FORSSK.	8	16	2.89 ± 0.16	1.47 ± 0.08	40.41	0.31	0.16	+	-	6	2
14	“	*Garhadiolus hedypnois* (FISH. et MEY.) JAUB. et SP.	6	12	2.99 ± 0.23	2.07 ± 0.29	34.00	0.46	0.19	-	-	2	4
15	“	*Hyoseris lucida* L.	8	16	1.92 ± 0.09	1.12 ± 0.03	47.27	0.10	0.13	-	1	7	-
16	“	*Lactuca sativa* L.	9	18	2.39 ± 0.21	1.65 ± 0.17	37.69	0.35	0.26	-	-	6	3
17	“	*L. serriola* L.	9	18	2.56 ± 0.09	1.35 ± 0.06	42.62	0.25	0.10	-	-	9	-
18	“	*Launaea capitata* (SPRENG.) DANDY	8	32	1.79 ± 0.07	1.17 ± 0.03	46.15	0.14	0.11	-	-	8	-
19	“	*L. cassiniana* (JAUB. et SP.) KUNTZE	8	32	1.72 ± 0.08	1.27 ± 0.07	44.24	0.20	0.14	-	-	8	-
20	“	*L. mucronata* (FORSSK.) MUSCHLER	8	16	1.70 ± 0.10	1.21± 0.03	45.14	0.17	0.17	-	-	8	-
21	“	*L. nudicaulis* (L.) HOOK. f.	9	18	2.47 ± 0.07	1.37 ± 0.08	42.65	0.25	0.09	+	-	8	1
22	“	*L. resedifolia* (L.) KUNTZE	8	16	1.86 ± 0.09	1.25 ± 0.07	44.81	0.18	0.13	-	-	8	-
23	“	*L. tenuiloba* (BOISS.) KUNTZE	8	16	1.72 ± 0.11	1.31 ± 0.08	43.36	0.21	0.18	-	-	8	-
24	“	*Picris damascena* BOISS. et GAILL.	5	10	2.67 ± 0.24	1.84 ± 0.08	35.53	0.45	0.20	-	-	1	4
25	“	*Reichardia picroides* (L.) ROTH	8	16	1.74 ± 0.11	1.31 ± 0.07	43.58	0.22	0.18	-	-	7	1
26	“	*R. tingitana* (L.) ROTH	8	16	1.85 ± 0.07	1.20 ± 0.04	45.77	0.16	0.11	-	-	8	-
27	“	*Sonchus macrocarpus* BOULOS & JEFFREY	8	32	1.50 ± 0.08	1.11 ± 0.05	47.42	0.09	0.15	-	-	8	-
28	“	*S. oleraceus* L.	8	32	1.30 ± 0.08	1.11 ± 0.03	47.55	0.19	0.17	-	1	7	-
29	“	*Thrincia tripolitana* SCH. BIP.	4	8	1.90 ± 0.16	1.89 ± 0.29	35.00	0.42	0.16	-	-	1	3
30	“	*Urospermum picroides* (L.) DESF.	5	10	1.56 ± 0.06	1.22 ± 0.09	45.01	0.17	0.09	-	-	5	-

MCL = Mean Chromosome Length
MAR = Mean Arm Ratio
M = Metacentric chromosome
SE = Standard Error
A_1 = intrachromosomal asymmetry index

m = metacentric region chromosome
sm = submetacentric chromosome
Chr. = Chromosome
TF % = Total Form percent
A_2 = interchromosomal asymmetry ind

Table 2. The cytological characters and its codes of the studied taxa

No.	Attributes	OTU's																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	Basic Chromosome number (*n*=4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2	Basic Chromosome number (*n*=5)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3	Basic Chromosome number (*n*=6)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Basic Chromosome number (*n*=8)	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	1	0	1	1	0	1	1	1	1	0	0
5	Basic Chromosome number (*n*=9)	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
6	Basic Chromosome number (*n*=10)	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Basic Chromosome number (*n*=11)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Basic Chromosome number (*n*=14)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Basic Chromosome number (*n*=17)	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Polyploidy Presence	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0
11	Presence of the SAT	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Chromosome Length: (1 – 2 µm)	1	1	0	1	0	1	1	1	0	1	1	0	0	0	1	0	0	1	1	1	0	1	1	0	1	1	1	1	1	1
13	Chromosome Length: (Above 2 µm)	0	0	1	0	1	0	0	0	1	0	0	1	1	1	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0
14	Arm Ratio: 1 – 1.7	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
15	Arm Radio: 1.7 – 3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
16	Total Form Percent: TF %(30 – 40%)	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0
17	Total Form Percent: TF %(40 – 50%)	1	1	0	1	0	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0	1
18	Chromosome Type: M	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
19	Chromosome Type: m	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	Chromosome Type: sm	0	0	1	1	1	0	1	1	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	1	1	0	0	0	1	0
21	A_1 Index: 0.00 – 0.10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
22	A_1 Index: 0.10 – 0.20	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	0	1	0	1	0	1
23	A_1 Index: 0.20 – 0.30	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0
24	A_1 Index: 0.30 – 0.40	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	A_1 Index: 0.40 – 0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
26	A_2 Index: 0.00 – 0.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
27	A_2 Index: 0.10 – 0.20	1	0	0	1	0	1	1	0	1	1	1	0	1	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	0
28	A_2 Index: 0.20 – 0.30	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	A_2 Index: 0.30 – 0.40	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Diversity of carpopodial structure in the Asteraceae and its taxonomic significance

Sobhan K. Mukherjee [1] & Bertil Nordenstam [2]
[1] Department of Botany, University of Kalyani, Kalyani- 741235,
West Bengal, India
e-mail: sobhankr@yahoo.com
[2] Department of Phanerogamic Botany, Swedish Museum of Natural History,
SE-104 05 Stockholm, Sweden
e-mail: bertil.nordenstam@nrm.se

Key words: Asteraceae, carpopodium, morphology, anatomy, classification, evolution.

Abstract

Presence and structure of carpopodia in 142 species belonging to 93 genera in four subfamilies and 17 tribes of the Asteraceae have been investigated in details with the help of LM and SEM. Abscission zone or carpopodium exists in between the receptacle and the base of cypsela. 14 types of carpopodia were recognized in the present study. True carpopodium is absent in several taxa belonging to 23 genera. Thickness of carpopodial cells is diacritical for some taxa and varies from 1 to 30 cell rows. The probable route of evolution of carpopodia in Asteraceae is outlined.

Introduction

According to Haque & Godward (1984) the term 'carpopodium' was first used by Mattfeld (1923), but cf. also below. Carpopodium is the basal abscission zone of the cypsela, which is attached to the receptacle and composed of one or more rows of cells, which are distinct morphologically from the rest of the cells of cypselar wall. Initial information about the different types of abscission zone of cypsela in Asteraceae was presented in the works of John (1921) and Vrgoč (1922).

This zone has been recognized as 'callus or podocarp' by Robinson (1913), 'carpopod' by Blake (1918), 'separation tissue' by Roth (1977), 'mechanical tissue' by Jeffrey (1987), or as 'carpopodium' by many authors after Mattfeld (e.g., Robinson & Brettell 1973, Robinson & King 1977, Wetter 1983, Jeffrey 1992, Short et al. 1989, Cron et al. 1993, Karis 1993, Bremer 1994). Carpopodium helps in cypselar detachment; consequently it is an important structure for active fruit dispersal. A few examples of the usefulness of carpopodium characters in taxonomy will be mentioned here.

The morphology, cell structure and the presence or absence of carpopodium along with other characters were used by KING & ROBINSON (1966) for the generic separation of the *Hofmeisteria* complex in the Eupatorieae, i.e. *Malperia*, *Hofmeisteria, Fleischmannia* and *Pleurocoronis*. ROBINSON & KING (1977) later identified five types of carpopodia in the Eupatorieae. They also emphasized the mode of orientation and wall thickness of carpopodial cells.

In Senecioneae, the morphology and cell structure of carpopodium have been used e.g. to segregate *Miricacalia* and *Koyamacalia* (now *Parasenecio*) from other cacalioid genera (ROBINSON & BRETTELL 1973) and two types of carpopodia were distinguished. JEFFREY (1987) recognized five carpopodial characters (as 'mechanical tissue') as useful descriptors in systematic studies of the Asteraceae. WETTER (1983) surveyed the cellular structure of the carpopodium in 31 species of New World Senecioneae, and he observed that the squarish to rectangular (quadrate) cells may be arranged in one or several series and that the number of series of cells is more or loss constant for each species. JEFFREY (1992) suggested three descriptive types of carpopodium size, viz., large (>6 rows of cells), medium (3–6 rows of cells) and small or absent (0–2 rows of cells). He also suggested descriptors for carpopodium margin, viz. regular vs. irregular or undulate margin.

HAQUE & GODWARD (1984) described the detailed carpopodial structures in some species of Asteraceae belonging to 18 genera, and eight types of carpopodia were designated with the help of SEM. They also observed the absence of a carpopodium in nine genera, or in present generic taxonomy actually ten genera.

The distinction of *Peteravenia cyrili-nelsonii* (KING & ROBINSON 1979) relies mainly upon microcharacters. The four other species of *Peteravenia* comprise a distinct species group, based on both macro- and microcharacters. The microcharacters of *P. cyrili-nelsonii* agree with those of the other four species of the genus, particularly in details of the carpopodial structure.

An investigation regarding the carpopodium along with other micromorphological characters was done in order to evaluate their utility as generic markers in the tribe Astereae by SUNDBERG (1985). According to him, carpopodial cells are either distinct morphologically from the cells of the cypselar wall, as in some species investigated, or not distinguishable from the rest of the cells of the pericarp in some other species. The shape of the carpopodium usually changes depending on the actual position of the cypsela on the receptacle. The characters of the carpopodial structure are, however, seemingly constant within a particular genus.

SHORT et al. (1989) have emphasized on the presence or absence of carpopodium in some members of the Inuleae, whereas KARIS (1993) has considered the length/breadth ratio of the carpopodial cells, and whether the carpopodium is well developed and sclerified, or carpopodium is absent or very obsolete. Examples of very distinct carpopodia (in genus *Baccharoides*, tribe Vernonieae) can be seen as SEM images in Isawumi et al. (1996, Figs. 15–22).

In most previous systems (Wagenitz 1976, Carlquist 1976, Jeffrey 1978, Robinson 1981, 1983, Thorne 1983, Bremer 1987), there are two well characterized subfamilies in Asteraceae, viz. Cichorioideae (or Lactucoideae) and Asteroideae. However in more recent classifications (Bremer & Jansen 1992, Bremer et al. 1992, Jansen et al. 1990, 1991, Kim et al. 1992, Bremer 1994, 1996), Asteraceae has three or four subfamilies (Barnadesioideae, Carduoideae, Cichorioideae and Asteroideae). The paraphyly of the Cichorioideae has been noted by some recent workers, particularly Kim & Jansen (1995), and most recently, a revision of subfamilial classification based on molecular phylogenetic studies has been proposed, resulting in a total of 11 subfamilies (Panero & Funk 2002). This recent classification affects some material included in our study, viz. *Ainsliaea*, now in tribe Pertyeae in subfamily Pertyoideae, and *Macledium*, now in tribe Dicomeae.

The present study deals with carpopodia of cypselas in 142 species belonging to 93 genera of four subfamilies or 15 (or 17) tribes. The main objectives are i) to present the various types of carpopodia in the Asteraceae, and ii) to elucidate the presence and structure of carpopodia in different tribes, and iii) to evaluate the phylogenetic and hence taxonomic significance of carpopodium structure.

Materials and methods

The present work has mainly been based on the study of dried cypselas from the following herbaria, abbreviated as in Holmgren et al. (1990): AD, BRI, LISC, NSW, RB, SRGH, TAI, and Z, but some cypselas were collected by the first author from different parts of India. Indian specimens were deposited in the Herbarium, Department of Botany, University of Kalyani, West Bengal, India, which is here named with a new herbarium acronym, KAL. Tribal classification of the Asteraceae largely follows Heywood et al. (1977) and Bremer (1994) with some modifications (cf. above). Genera and species are arranged in alphabetical sequence.

For microscopical investigation, mature dry cypselas were rehydrated in boiling water and fixed in FAA solution (Johansen 1940). Entire cypselas or basal half of cypselas were boiled in saturated chloral hydrate solution for 1–6 minutes, washed with water, stained in 0.5% aqueous safranin solution and mounted in 70% phenol glycerine solution. Pretreated unstained cypselas or basal part of cypselas were also stained in phloroglucin with HCL for demonstration of carpopodial cells. In some cases, LS and RLS of the carpopodial region were stained in aforesaid procedures and were mounted for observation of cellular structure of the carpopodial cells. For each species at least five randomly selected cypselas were studied.

For SEM observation, entire cypselas were mounted on stubs and were processed using standard SEM techniques. Photographs were taken in Philips SEM at R. S. I. C. of Bose Institute, Calcutta, W. B., India.

Sources of cypselas

Tribe Eupatorieae – *Ageratina riparia* (Regel) R. M. King & H. Rob., BRI; s.n., s. coll. *Eupatorium cannabinum* L., Z; Nr. 392. *Eupatorium chinense* L. var. *tozanense* (Hay.) Kitamura, TAI; Y. F. Chen 3898. *Eupatorium formosanum* Hay., TAI; Y. F. Chen 3819. *Heterocondylus vitalbis* (DC.) R. M. King & H. Rob., RB; SN 252. *Liatris spicata* Willd., Z, Nr. 414. *Mikania trinervis* Hook. & Clus., RB; SN 253.

Tribe Vernonieae – *Baccharoides anthelmintica* (L.) Moench, KAL; S. Mukherjee 1. *Baccharoides calvoana* (Hook. f.) Isawumi, El-Ghazaly & B. Nord. ssp. *meridionalis* (Wild) Isawumi, El-Ghazaly & B. Nord., SRGH; G. Pope 1930. *Bothriocline laxa* N. E. Br. ssp. *laxa*, SRGH; M. Mavi 11. *Centrapalis kirkii* (Oliv. & Hiern) H. Rob., LISC; F. A. Mendonca 2033. *Elephantopus scaber* L., RB; SN 257. *Lepidaploa gracilis* (H.B.K.) H. Rob., RB; SN 250. *Linzia melleri* (Oliv. & Hiern) H. Rob., LISC; R. Santos 2051. *Polydora bainesii* (Oliv. & Hiern) H. Rob., SRGH; G. Pope 1929. *Polydora poskeana* (Vatke & Hildeb.) H. Rob., LISC; A. R. Torre & Paiva 11332. *Rolandra fruticosa* (L.) O. Kuntze, RB; SN 255. *Vanillosmopsis capitata* (Spr.) Sch.Bip., RB; SN 248. *Vernonanthura condensata* (Baker) H. Rob., RB; SN 249. *Vernonanthura diffusa* (Less.) H. Rob., RB; SN 254. *Vernonia cistifolia* O. Hoffm., SRGH; G. Pope 1931. *Vernonia glabra* (Willd.) Vatke, SRGH; M. Mavi 12. *Vernonia petersii* Oliv. & Hiern, LISC; A. R. Torre 118. *Vernonia scorpioides* (Lam.) Pers., RB; SN 251. *Vernonia senegalensis* Less., LISC; Schlieben 2457.

Tribe Astereae – *Aster amellus* L., Z; Nr. 350. *Aster peduncularis* Wall. ex Nees, KAL; S. Mukherjee 2. *Aster thomsonii* C. B. Clarke, KAL; S. Mukherjee 3. *Baccharis halimifolia* L., Z; Nr. 353. *Brachycome campylocarpa* J. M. Black, NSW; L. Haegi 2065. *Brachycome ciliaris* (Labill.) Less. var. *ciliaris*, NSW; L. Haegi 2105. *Brachycome curvicarpa* G. L. Davis, NSW; L. Haegi 2066. *Brachycome heterodonta* DC. var. *heterodonta*, NSW; L. Haegi 2064. *Brachycome parvula* Hook. f. var. *lissocarpa* (J. M. Black) G. L. Davis, AD; A. A. Munir 5404. *Erigeron acer* L., Z; Nr. 388. *Erigeron villarsii* Bell., Z; Nr. 389. *Myriactis humilis* Merrill, TAI; Y. F. Chen 3363. *Vittadinia gracilis* (Hook. f.) Burbidge, AD; N. N. Donner 8633.

Tribe Inuleae s. lat. (Inuleae, Plucheeae, Gnaphalieae) – *Actinobole uliginosum* (A.Gray) Eichler, NSW; L. Haegi 2112. *Athrixia phylicoides* DC., SRGH; M. Mavi 14. *Buphthalmum salicifolium* L., Z; Nr. 356. *Carpesium cernuum* L., Z; Nr. 362. *Carpesium nepalense* Less., KAL; S. Mukherjee 4. *Chrysocephalum apiculatum* (Labill.) Steetz, NSW; L. Haegi 2133. *Craspedia uniflora* Forst. f., AD; A. A. Munir 5498. *Gamochaeta pensylvanica* (Willd.) Cabrera (=*Gnaphalium purpureum* subsp. *pensylvanicum*), SRGH; M. Mavi 3. *Helichrysum cephaloideum* DC., SRGH; G. Pope 1916. *Helichrysum nitens* Oliv. & Hiern, SRGH; G. Pope 1926. *Helichrysum odoratissimum* (L.) Sweet, SRGH; G. Pope 1921. *Helichrysum umbraculigerum* Less., SRGH; G. Pope 1927. *Inula ensifolia* L., Z; Nr. 405. *Myriocephalus stuartii* (F. Muell. & Sond. ex Sond.) Benth., NSW; L. Haegi 2128. *Pterocaulon sphacelatum* (Labill.) F. Muell., NSW; L. Haegi 2117. *Pulicaria angustifolia* DC., KAL; S. Mukherjee 5. *Rhodanthe corymbiflora* (Schlecht.) P. G. Wilson, NSW; L. Haegi 2076. *Rhodanthe floribunda* (DC.) P. G. Wilson, NSW; L. Haegi 2160. *Rhodanthe humboldtiana* (Gaudich.) P. G. Wilson, Z; Nr. 401. *Rhodanthe moschata* (A. Cunn. ex DC.) P. G. Wilson, NSW; L. Haegi 2096. *Rhodanthe uniflora* (J. M. Black) P. G. Wilson, NSW; L. Haegi 2093. *Rutidosis helichrysoides* DC., NSW; L. Haegi 2107. *Rutidosis multiflora* (Nees) B. L. Robinson, AD; A. A. Munir 5509. *Triptilodiscus pygmaeus* Turcz. (*Helipterum australe* (A. Gray) Druce), NSW; L. Haegi 2109. *Xerochrysum bracteatum* (Vent.) N. N. Tsvelev, Z; Nr. 399. *Xerolekia speciosissima* (L.) A. A. Anderb., Z; Nr. 357.

Tribe Heliantheae – *Arnica chamissonis* Less., Z; Nr. 347. *Bidens biternata* (Lour.) Merr. & Sherff, KAL; S. Mukherjee 6. *Bidens cernua* L., Z; Nr. 354. *Bidens pilosa* L., KAL; S. Mukherjee 7. *Bidens tenuifolia* Labill. (*Glossogyne tenuifolia* Cass.), BRI; s. n., s. coll. *Chrysanthellum americanum* (L.) Vatke, KAL; S. Mukherjee 8. *Coreopsis tinctoria* Nutt., Z; Nr. 381. *Cosmos sulphureus* Cav., Z; Nr. 382. *Echinacea purpurea* Moench, Z; Nr. 385. *Gaillardia aristata* Pursh, Z; Nr. 395. *Glossocardia bidens* (Retz.) J. F. Veldkamp, KAL; S. Mukherjee 9. *Helianthus annuus* L., Z; Nr. 398. *Tithonia diversifolia* (Hemsl.) A. Gray, BRI; s. n., s. coll. *Tithonia rotundifolia* (Mill.) Blake, SRGH; M. Mavi 17. *Xanthium pungens* Wallroth, BRI; s. n., s. coll.

Tribe Tageteae – *Tagetes minuta* L., BRI; s. n., s. coll.

Tribe Senecioneae – *Cissampelopsis volubilis* (Blume) Miq., KAL; S. Mukherjee 15. *Crassocephalum crepidioides* (Benth.) S. Moore, BRI; s. n., s. coll. *Crassocephalum rubens* (Juss. ex Jacq.) S. Moore, SRGH; M. Mavi 13. *Emilia discifolia* (Oliv.) C. Jeffrey, SRGH; M. Mavi 1. *Emilia flammea* Cass., Z; Nr. 389. *Erechtites quadridentata* (Labill.) DC., AD; A. A. Munir 5533. *Erechtites valerianifolia* (Wolf) DC., BRI; s. n., s. coll. *Ligularia dentata* (A. Gray) Hara, Z; Nr. 415. *Senecio edgeworthii* Hook. f., KAL; S. Mukherjee 11. *Senecio hewrensis* Hook. f., KAL; S. Mukherjee 12. *Senecio laceratus* (F. Muell.) Belcher, AD; N. N. Donner 8595. *Senecio lautus* Forst. f. ex Willd. ssp. *dissectifolius* Ali, AD; A. A. Munir 5338. *Senecio lautus* Forst. f. ex Willd. ssp. *maritimus* Ali, AD; A. A. Munir 5574. *Senecio wightii* (Wall.) Benth., KAL; S. Mukherjee 16. *Steirodiscus tagetes* (L.) Schltr. (*Gamolepis annua* Less.), Z; Nr. 396. *Synotis acuminata* (Wall. ex DC.) C. Jeffrey & Y.L. Chen, KAL; S. Mukherjee 10. *Synotis kunthiana* (Wall. ex DC.) C. Jeffrey & Y.L. Chen, KAL; S. Mukherjee 13. *Synotis triligulata* (Buch.-Ham. ex. D. Don) C. Jeffrey & Y. L. Chen, KAL; S. Mukherjee 14.

Tribe Anthemideae – *Achillea ageratifolia* (SIBTH. & SM.) BOISS., Z; Nr. 335. *A. macrophylla* L., Z; Nr. 337. *Anacyclus depressus* BALL, Z; Nr. 339. *Anthemis tinctoria* L., Z; Nr. 342. *Leucanthemum weyrichii* (MAXIM.) MIYABE & MIYAKE, Z; Nr. 373. *Cladanthus arabicus* (L.) CASS., Z; Nr. 379. *Matricaria maritima* L., Z; Nr.374. *Tanacetum macrophyllum* (WALDST. & KIT.) SCH.BIP., Z; Nr. 373.

Tribe Arctoteae – *Arctotheca calendula* (L.) LEVYNS, AD; N. N. DONNER 8541. *Arctotis venusta* NORLINDH, Z; Nr. 345. *Berkheya zeyheri* (SOND. & HARV.) OLIV. & HIERN ssp. *zeyheri*, LISC; A. R. TORRE 6907.

Tribe Calenduleae – *Calendula officinalis* L., Z; Nr. 358. *Dimorphotheca pluvialis* (L.) MOENCH, Z; Nr. 384.

Tribe Cynareae – *Arctium lappa* L., Z; Nr. 343. *Carduus defloratus* L., Z; Nr. 359. *Carlina acanthifolia* ALL. ssp. *cynara* (POURRET ex DUBY) ROUY, Z; Nr. 360. *Carlina vulgaris* L. ssp. *vulgaris*, Z; Nr. 361. *Centaurea cyanus* L., Z; Nr. 364. *Centaurea macrocephala* MUSS.-PUSCHK. ex WILLD., Z; Nr. 366. *Centaurea maculosa* LAM. ssp. *maculosa*, Z; Nr. 369. *Cirsium japonicum* DC., Z; Nr. 378. *Cirsium vulgare* (SAVI) TEN., BRI; s. n., s. coll. *Echinops sphaerocephalus* L., Z; Nr. 386. *Leuzea rhapontica* (L.) J. HOLUB, Z; Nr. 413. *Ptilostemon diacanthus* (LABILL.) GREUTER, Z; Nr. 377.

Tribe Pertyeae - *Ainsliaea latifolia* (D. DON) SCH.-BIP., KAL; S. MUKHERJEE 17. *Ainsliaea reflexa* MERRILL var. *nimborum* HAND.-MAZZ., TAI; Y. F. CHEN 3300.

Tribe Mutisieae s. lat. (incl. Dicomeae) – *Gerbera jamesonii* BOLUS ex HOOK. F., Z; Nr. 397. *Macledium sessiliflorum* (HARV. in HARV. & SOND.) S. ORTIZ ssp. *sessiliflorum*, LISC; A. R. TORRE 13.

Tribe Lactuceae – *Actites megalocarpa* (HOOK. F.) LANDER , AD; A. A. MUNIR 5512. *Catananche caerulea* L., Z; Nr. 363. *Cicerbita cyanea* (D. DON) BEAUV., KAL; S. MUKHERJEE 18. *Cicerbita macrorhiza* (ROYLE) BEAUV., KAL; S. MUKHERJEE 19. *Crepis pyrenaica* (L.) GREUTER, Z; Nr. 383. *Crepis vesicaria* L., AD; N. N. DONNER 8607. *Hieracium villosum* JACQ., Z; Nr. 404. *Hypochaeris glabra* L., AD; A. A. MUNIR 8601. *Hypochaeris radicata* L., BRI; s. n., s. coll. *Lactuca serriola* L., BRI; s.n., s. coll. *Leontodon autumnalis* L., Z; Nr. 409. *Sonchus brachyotus* DC., KAL; S. MUKHERJEE 20. *Sonchus schweinfurthii* OLIV. & HIERN, SRGH; M. MAVI 8. *Taraxacum officinale* (L.) G. WEBER, AD; A. A. MUNIR 5500. *Tragopogon porrifolius* L., AD; N. N. DONNER 8606.

Results

The characteristic features of carpopodium in different species are summarized in the following Table 1.

Table 1. Different types of carpopodia in Asteraceae in the present study

Tribe, genus and species	Presence or absence of carpo-podium	Carpopodium as wide as (S) or wider (W) or narrower (N) than the base of cypsela	Type of carpopodium	Thickness of carpopodium in no. of cell rows or any special character
Tribe Eupatorieae				
Ageratina riparia	+	S	Symmetric, complete ring	10 – 15
Eupatorium cannabinum (Fig. 1)	+	S	Morphologically symmetric & ring-like, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Eupatorium chinense var. *tozanense* (Fig. 2)	+	W	Poorly differentiated	1
Eupatorium formosanum	+	S	Morphologically symmetric & ring-like, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Heterocondylus vitalbis	+	W	Symmetric, complete ring	12 – 18
Liatris spicata	+	S	Symmetric, complete ring	12 – 18
Mikania trinervis (Figs. 3, 4)	+	S	Asymmetric, cup-like with unequal lobes at the apex	15 - 20
Tribe Vernonieae				
Baccharoides anthelmintica	+	N	Symmetric, complete ring	5 – 8
Baccharoides calvoana ssp. *meridionalis*	+	W	Symmetric, complete ring	20 – 25
Bothriocline laxa ssp. *laxa*	+	N	Symmetric, complete ring	3 – 4
Centrapalis kirkii (Fig. 6)	+	W	Symmetric, cup-like with 5–6 shallow apical furrows	20 – 30
Elephantopus scaber	+	S	Symmetric, complete ring	5 – 7
Lepidaploa gracilis	+	S	Symmetric, complete ring	12 – 15
Linzia melleri	+	W	Symmetric, disc-like complete ring	7 – 10
Polydora bainesii	+	W	Symmetric, complete ring	5 – 11
Polydora poskeana	+	S	Symmetric, complete ring	2 – 6
Rolandra fruticosa	+	S	Symmetric, complete wavy ring	4 – 10
Vanillosmopsis capitata (Fig. 5)	+	W	Asymmetric, complete ring	3 – 4
Vernonanthura condensata	+	S	Symmetric, complete ring	11 – 17
Vernonanthura diffusa	+	W	Symmetric, complete ring	10 – 17
Vernonia cistifolia	+	S	Symmetric, complete ring	10 – 15
Vernonia glabra	+	W	Symmetric, complete ring	7 – 11
Vernonia petersii (Fig. 30)	+	S	Symmetric, complete ring	5 - 8
Vernonia scorpioides	+	S	Symmetric, complete ring	4 – 6
Vernonia senegalensis (Fig. 31)	+	W	Symmetric, complete ring	17 – 25

Tribe Astereae				
Aster amellus (Fig. 32)	+	S	Asymmetric, complete ring	6 – 10
Aster peduncularis	+	S	Asymmetric, complete ring	3 - 7
Aster thomsonii	+	S	Asymmetric, complete ring	6 – 12
Baccharis halimifolia (Fig. 33)	+	S	Asymmetric, complete ring	5 – 8
Brachycome campylocarpa	-			
Brachycome ciliaris var. *ciliaris*	+	N	Symmetric, complete ring	3 – 4
Brachycome curvicarpa	+	N	Symmetric, complete ring	4 – 5
Brachycome heterodonta var. *heterodonta*	+	N	Poorly differentiated	1
Brachycome parvula var. *lissocarpa*	+	S	Symmetric, complete ring	2 – 4
Erigeron acer	+	S	Asymmetric, complete ring	8 – 12
Erigeron villarsii (Fig. 34)	+	S	Asymmetric, complete ring	8 – 12
Myriactis humilis	-			
Vittadinia gracilis (Fig. 7)	+	N	Asymmetric, complete ring	4 – 7
Tribe Inuleae s. lat.				
Actinobole uliginosum	+	N	Symmetric, tubular complete ring	2 – 3
Athrixia phylicoides (Fig. 8)	+	S	Asymmetric, complete ring	5 – 11
Buphthalmum salicifolium	-			
Carpesim cernuum	-			
Carpesium nepalense	-			
Chrysocephalum apiculatum	+	N	Asymmetric, disc-like complete ring	3 – 4
Craspedia uniflora (Fig. 9)	+	S	Asymmetric, disc-like complete ring	3 – 4
Gamochaeta pensylvanica (Fig. 35)	+	N	Poorly differentiated	1
Helichrysum cephaloideum	+	N	Asymmetric, disc-like complete ring	3 – 4
Helichrysum nitens	+	S	Symmetric, complete ring	5 – 6
Helichrysum odoratissimum	+	N	Asymmetric, complete ring	2 – 4
Helichrysum umbraculigerum (Fig. 10)	+	N	Asymmetric, complete ring	2 – 4
Inula ensifolia	+	S	Symmetric, complete ring	4 – 6
Myriocephalus stuartii	+	S	Symmetric, complete ring	4 – 6
Pterocaulon sphacelatum	+	S	Symmetric, complete ring	4 – 6
Pulicaria angustifolia	+	S	Asymmetric, complete ring	12 – 17
Rhodanthe corymbiflora	+	S	Poorly differentiated	1
Rhodanthe floribunda	+	S	Poorly differentiated	1
Rhodanthe humboldtiana (Fig. 11)	+	S	Asymmetric, disc-like complete ring	5 – 8
Rhodanthe moschata	+	S	Asymmetric, complete ring	3 – 5
Rhodanthe uniflora	+	S	Asymmetric, complete ring	4 – 6
Rutidosis helichrysoides	+	S	Symmetric, complete ring	3 –5
Rutidosis multiflora	+	S	Morphologically inconspicuous ring-like, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Triptilodiscus pygmaeus	+	S	Asymmetric, complete ring	5 – 7
Xerochrysum bracteatum	+	N	Poorly differentiated	1
Xerolekia speciosissima	-			

Tribe Heliantheae				
Arnica chamissonis	+	W	Symmetric, complete ring	3 – 6
Bidens biternata	+	S	Asymmetric, ring-like 2-lobed	3 – 5
Bidens cernua	-			
Bidens pilosa	-			
Bidens tenuifolia	+	W	Asymmetric, lobed complete ring	5 – 9
Chrysanthellum americanum	-			
Coreopsis tinctoria	-			
Cosmos sulphureus (Fig. 12)	+	S	Asymmetric, complete ring, turned to one side	5 – 6
Echinacea purpurea	-			
Gaillardia aristata	-			
Glossocardia bidens (Fig. 13)	+	S	Asymmetric, 5-angled complete ring	8 – 15
Helianthus annuus	+	S	Asymmetric, in two opposite sections	7 – 12
Tithonia diversifolia (Fig. 14)	+	S	Asymmetric, in two opposite sections	7 – 12
Tithonia rotundifolia	+	S	Asymmetric, in two opposite sections	8 – 15
Xanthium pungens	-			
Tribe Tageteae				
Tagetes minuta	+	S	Asymmetric, complete ring, turned to one side	6 – 20
Tribe Senecioneae				
Cissampelopsis volubilis	+	S	Symmetric, complete ring	6 – 8
Crassocephalum crepidioides (Figs. 15, 16)	+	S	Asymmetric, 4-angled complete ring	2
Crassocephalum rubens	+	S	Symmetric, 3–4-angled compete ring	3 – 4
Emilia discifolia	+	N	Asymmetric, 5-angled complete ring	2 – 4
Emilia flammea (Fig. 36)	+	S	Poorly differentiated	1
Erechtites quadridentata	+	S	Asymmetric, complete ring	3 – 4
Erechtites valerianifolia	+	S	Poorly differentiated	1
Ligularia dentata (Fig. 17)	+	S	Symmetric, complete ring	3 – 6
Senecio edgeworthii (Fig. 18)	+	S	Asymmetric, complete ring	3 – 6
Senecio hewrensis (Fig. 19)	+	S	Asymmetric, nearly complete ring, with one marked interruption	3 – 5
Senecio laceratus	+	S	Asymmetric, distorted or lacerated	3 – 6
Senecio lautus ssp. *dissectifolius*	+	S	Poorly differentiated	1
Senecio lautus ssp. *maritimus*	+	S	Poorly differentiated	1
Senecio wightii	+	S	Asymmetric, complete ring	4 – 8
Steirodiscus tagetes	+	S	Morphologically symmetric ring, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Synotis acuminata	+	W	Asymmetric, complete ring	7 – 12
Synotis kunthiana	+	S	Asymmetric, complete ring	6 – 8
Synotis triligulata	+	S	Asymmetric, complete ring	6 – 8

Tribe Anthemideae				
Achillea ageratifolia	+	S	Symmetric, complete triangular ring	4 – 6
Achillea macrophylla	+	S	Symmetric, complete triangular ring	4 – 6
Anacyclus depressus	-			
Anthemis tinctoria (Figs. 20, 21)	+	S	Poorly differentiated	1
Cladanthus arabicus	+	S	Morphologically asymmetric ring, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Leucanthemum weyrichii (Fig. 37)	+	S	Asymmetric, complete ring	10 – 17
Matricaria maritima	+	S	Symmetric, complete ring	3 – 5
Tanacetum macrophyllum	+	S	Asymmetric, complete ring	4 – 7
Tribe Arctoteae				
Arctotheca calendula	-			
Arctotis venusta	-			
Berkheya zeyheri ssp. *zeyheri* (Fig. 22)	+	S	Asymmetric, two opposite sections	4 – 6
Tribe Calenduleae				
Calendula officinalis	+	N	Morphologically inconspicuous, ring-like, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Dimorphotheca pluvialis	+	N	Morphologically present, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Tribe Cynareae				
Arctium lappa	-			
Carduus defloratus	-			
Carlina acanthifolia	+	N	Morphologically ring-like, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Carlina vulgaris	+	S	Asymmetric, complete ring	4 – 5
Centaurea cyanus	+	S	Strongly asymmetric, a band of thick-walled cells around the base, to form a continuous ring	Cell layer thickness not countable
Centaurea macrocephala (Fig. 23)	+	S	Strongly asymmetric, a band of thick-walled cells around the base, to form a continuous ring	Cell layer thickness not countable
Centaurea maculosa ssp. *maculosa* (Fig. 38)	+	S	Strongly asymmetric, a band of thick-walled cells around the base, to form a continuous ring	Cell layer thickness not countable
Cirsium japonicum	+	S	Strongly asymmetric, a band of non-thickened cells around the base, to form a continuous ring	Cell layer thickness not countable
Cirsium vulgare	+	S	Strongly asymmetric, deeply 6–10-lobed interrupted ring	Cell layer thickness not countable
Echinops sphaerocephalus	+	N	Symmetric, complete ring	4 – 7
Leuzea rhapontica (Fig. 24)	+	N	Poorly differentiated	1
Ptilostemon diacanthus	-			

Tribe Pertyeae				
Ainsliaea latifolia (Fig. 39)	+	W	Symmetric, disc-like complete ring	2 – 17 cells, vertically oriented
Ainsliaea reflexa var. *nimborus*	+	S	Symmetric, disc-like complete ring	2 – 17 cells, vertically oriented
Tribe Dicomeae				
Macledium sessiliflorum ssp. *sessiliflorum*	-			
Tribe Mutisieae				
Gerbera jamesonii	-			
Tribe Lactuceae				
Actites megalocarpa	-			
Catananche caerulea (Fig. 40)	+	W	Strongly asymmetric, one-sided	10 – 13
Cicerbita cyanea	+	S	Asymmetric, complete ring	3 – 5
Cicerbita macrorhiza	+	S	Asymmetric, complete ring	3 – 4
Crepis pyrenaica (Fig. 41)	+	S	Asymmetric, 4–6-lobed ring	10 – 15
Crepis vesicaria (Fig. 25)	+	S	Asymmetric, 5-lobed ring, 2 lobes larger and more projecting	8 – 12
Hieracium villosum (Fig. 26)	+	N	Asymmetric, nearly complete ring with one marked interruption	1 – 5
Hypochaeris glabra (Fig. 27)	+	S	Asymmetric, 4-lobed ring, with one large strongly projecting lobe	3 – 5
Hypochaeris radicata	+	S	Asymmetric, 5-lobed ring, with one larger projecting lobe	3 – 5
Lactuca serriola (Fig. 28)	+	S	Asymmetric, nearly complete ring with one narrow interruption	3 – 6
Leontodon autumnalis (Fig. 29)	+	S	Morphologically symmetric complete ring, but anatomically absent (pseudo-carpopodium)	Thick-walled carpopodial cells absent
Sonchus brachyotus	-			A few slightly thickened cells present near base
Sonchus schweinfurthii	-			
Taraxacum officinale	-			
Tragopogon porrifolius	-			

Discussion

The present study indicates that carpopodial structures show few or no correlations between the four subfamilies of Asteraceae studied, i.e. Carduoideae, Pertyoideae, Cichorioideae and Asteroideae. The presence or absence of carpopodium and its structure (i.e., types, symmetry, arrangement, thickness and number of carpopodial cells) are diacritical taxonomic parameters. Usually the orientation of carpopodial cells and the number of rows of carpopodial cells are more or less constant in each species.

When a true carpopodium is absent the abscission zone or thick-walled carpopodial cells are lacking, as in *Actites*, *Anacyclus, Arctium, Arctotheca, Arctotis, Bidens* (2 spp.), *Brachycome campylocarpa, Buphthalmum, Carduus, Carpesium, Chrysanthellum, Coreopsis, Echinacea, Gaillardia, Gerbera, Macledium, Myriactis, Ptilostemon, Sonchus, Taraxacum, Tragopogon, Xanthium* and *Xerolekia.* Here carpopodium is absent morphologically as well as anatomically. HAQUE & GODWARD (1984) have reported the absence of carpopodium from nine genera including *Arctotis, Tragopogon,* and four species of *Senecio*. Present study shows that all six species of *Senecio* studied (plus one now in *Emilia*) have distinct carpopodia.

There is another type of cypsela which bears a basal ring morphologically similar to a small carpopodium (observed in *Calendula, Carlina acanthifolia, Cladanthus, Dimorphotheca, Eupatorium cannabinum & formosanum, Leontodon, Rutidosis multiflora* and *Steirodiscus*) but this ring, or annulus, is not formed by thick-walled carpopodial cells but cells identical with other pericarpic cells. Such type of carpopodium-like structure may be termed "pseudo-carpopodium", when a true carpopodium is anatomically absent but seemingly present morphologically.

The walls of carpopodial cells usually have a characteristic lignified thickening, which is absent in adjacent pericarpic cells. Therefore in mature cypselas, carpopodial cells do not contract but the pericarpic cells will contract. Thus an uneven tension pressure will be produced in the basal zone and which may be responsible for the active detachment followed by dispersal of cypselas from receptacle (cf. HAQUE & GODWARD 1984).

Often carpopodial cells are arranged in two to many rows, but in cypselas with a poorly differentiated carpopodium the abscission zone may or may not be visible externally, although having one row of thick-walled carpopodial cells. These can be made visible under light microscope after clearing. This is the case in *Anthemis, Brachycome heterodonta* var. *heterodonta, Emilia flammea, Erechtites valerianifolia, Eupatorium chinense, Gamochaeta, Leuzea, Rhodanthe corymbiflora & floribunda, Senecio lautus* and *Xerochrysum bracteatum.*

Identical arrangement of cells has been reported by WETTER (1983) in *Senecio cineraria* and *S. vulgaris*, and he noted the distinction in this character of *Senecio* from other, especially cacalioid genera. Presence of a distinct carpopodium in the senecioid genus *Cineraria* was also reported by CRON et al. (1993), and carpopodium characteristics have been mentioned in many other recent papers on this and other tribes.

The carpopodium may be symmetric or asymmetric. A flattened cypsela commonly has a moderately asymmetric type of carpopodium. A winged cypsela with a broad base usually possesses a small symmetrical carpopodium.

Druses were not found in the carpopodial cells, although SUNDBERG (1985) has noted that carpopodial cells may contain druses. He also mentioned that "The cypselas with rounded bases often lack true carpopodium", but this statement may not be always true. Many cypselas from the present study have in fact a rounded base with true carpopodium.

Usually the diameter of carpopodium is same as the base of the cypsela, although in some species carpopodium is wider than the base, while fewer species have narrower carpopodium.

SHORT et al. (1989) have noted that a prominent annular carpopodium exists in *Craspedia, Chrysocephalum* (as *'Helichrysum'*), *Rhodanthe (*as *'Helipterum'), Myriocephalus stuartii, Rutidosis helichrysoides* and others. They did not observe the thickness of carpopodial cell layer in terms of number of cell rows, which are mentioned in the present study.

On the basis of presence or absence of thick-walled cells of carpopodia and the number of tires or rows of carpopodial cells, the carpopodia can be divided into two broad groups and altogether six kinds, as follows.

I. Primitive carpopodia.

Thick-walled carpopodial cells are absent, or carpopodia are formed by only thin-walled cells, or carpopodial cells are represented by a single row of thick-walled cells.

In this group there are three kinds:

i) **True carpopodium absent** (carpopodium absent both morphologically and anatomically). This kind lacks both carpopodium-like structure and thick-walled carpopodial cells, e.g., *Anacyclus, Arctotheca, Arctotis, Bidens* (2 species), *Brachycome campylocarpa, Buphthalmum, Carpesium, Chrysanthellum, Coreopsis, Gaillardia, Gerbera, Macledium, Myriactis, Rutidosis, Sonchus, Taraxacum, Tragopogon* and *Xanthium.*

ii) **Pseudo-carpopodium** (carpopodium morphologically present but anatomically absent). In this kind the cypsela has externally a carpopodium-like structure which is formed by thin-walled pericarpic cells. Thick-walled carpopodial cells are absent, e.g., *Calendula, Carlina acanthifolia, Cladanthus, Eupatorium cannabinum & formosanum, Dimorphotheca, Leontodon, Rutidosis multiflora* and *Steirodiscus.*

iii) **Poorly differentiated carpopodium**. Carpopodium may be externally visible or may not be recognized as a definite structure, but it is always associated with a single row of thick-walled carpopodial cells, e.g., *Anthemis, Brachycome heterodonta* var. *heterodonta, Emilia flammea, Erechtites valerianifolia, Eupatorium chinense, Gamochaeta, Rhodanthe corymbiflora & floribunda, Leuzea, Senecio lautus* and *Xerochrysum.*

II. **Advanced carpopodia.** Carpopodia are always formed by two to many rows of thick-walled carpopodial cells.

In this group there are three kinds:

i) **Poorly advanced.** This kind is very rare. The thickness of carpopodia is nearly constantly two rows or tires of cells, e.g., *Crassocephalum crepidioides* and *Emilia discifolia.*

ii) **Moderately advanced.** This is the most common kind, where thickness of carpopodium varies from 3–9 cell rows or tires, and found in the majority of taxa.

iii) **Highly advanced.** Less frequent than the previous one; thickness of carpopodium varies from 10–30 rows or tires of cells, e.g., *Ageratina riparia, Ainsliaea latifolia, Baccharoides calvoana* ssp. *meridionalis, Catananche caerulea, Centrapalis kirkii, Crepis pyrenaica, Heterocondylus vitalbis, Lepidaploa gracilis, Leucanthemum weyrichii, Liatris spicata, Pulicaria angustifolia, Vernonia cistifolia & senegalensis.*

The present study indicates that, out of 14 (or 17) studied tribes, the asymmetric type of carpopodia is prevalent in six (or eight) tribes (Arctoteae, Cynareae, Heliantheae, Inuleae s. lat., Lactuceae and Tageteae), whereas the symmetric type is predominant in four tribes (Calenduleae, Eupatorieae, Pertyeae, and Vernonieae). Remaining tribes (Anthemideae, Astereae and Senecioneae) have both symmetric and asymmetric types of carpopodia or no carpopodium (Mutisieae and Dicomeae).

Within a tribe, some taxa have primitive carpopodia, whereas other taxa bear advanced carpopodia. Therefore, on this character alone the tribe cannot be regarded as advanced or primitive. So, the development of carpopodia is heterobathmic.

Distinguished authors in different times have considered various tribes of the Asteraceae as primitive, such as the Heliantheae (BENTHAM 1873, CRONQUIST 1955), the

Senecioneae (SMALL 1919), the Cynareae (or Cardueae, LEONHARDT 1949), the Vernonieae (AUGIER & DU MERAC 1951), the Mutisieae (CARLQUIST 1976, JEFFREY 1977), the Eupatorieae (ROBINSON 1981), the Cynareae (Cardueae) and the Vernonieae (BREMER 1987), and the Barnadesieae and the Mutisieae (BREMER 1996) as most primitive. On the basis of nature of carpopodium in our limited study, it is not possible to draw any conclusions on which tribe is the most primitive or which one is the most advanced.

The structure of carpopodium varies when viewed from the top or from the side. In spite of that a number of different types of carpopodia have been observed and presented below with some examples. The number of species examined in each genus is also given in parenthesis, if more than one species of a genus was examined.

(i) Carpopodium lacking. In many members of the family Asteraceae a true carpopodium is absent both morphologically and anatomically, i.e., thick-walled carpopodial cells are absent; examples are mentioned earlier.

(ii) 'Pseudo-carpopodium'. Morphologically carpopodium is present, but it is absent anatomically. In this case, thick-walled carpopodial cells are also absent and the carpopodium-like structure is formed by thin-walled pericarpic cells. That is why we term this 'pseudo-carpopodium'. Examples are mentioned earlier.

(iii) Poorly differentiated carpopodium, which is represented by a single row of thick-walled carpopodial cells. Thin-walled cells are present above the thickened cells. Examples are noted earlier.

(iv) Complete ring-like symmetric carpopodium. It is the most common type; e.g. *Achillea* (2), *Actinobole, Ageratina, Ainsliaea* (2), *Arnica, Baccharoides* (2), *Bothriocline, Brachycome* (3), *Cissampelopsis, Echinops, Elephantopus, Heterocondylus, Inula, Lepidaploa, Liatris, Linzia, Matricaria, Myriocephalus, Polydora* (2), *Pterocaulon, Rolandra, Rutidosis helichrysoides*, *Vernonanthura* (2) and *Vernonia* (5).

(v) Complete ring-like asymmetric carpopodium. This is also prevalent in Asteraceae; e.g., *Aster* (3), *Athrixia, Baccharis, Bidens tenuifolia*, *Carlina vulgaris, Chrysocephalum, Emilia discifolia, Leucanthemum, Cicerbita* (2), *Craspedia, Erigeron* (2), *Glossocardia*, *Helichrysum* (4), *Pulicaria*, *Rhodanthe* (3), *Senecio* (2), *Synotis* (3), *Tanacetum*, *Triptilodiscus*, *Vanillosmopsis* and *Vittadinia.*

(vi) Complete ring-like strongly asymmetric carpopodium, which is turned to one side; e.g., *Cosmos, Tagetes.*

(vii) Distorted or lacerated asymmetric carpopodium; e.g., *Senecio laceratus*.

(viii) Interrupted ring-like, deeply 6–10-lobed, asymmetric carpopodium; e.g., *Cirsium vulgare.*

(ix) Interrupted ring-like, 4–6-lobed, asymmetric carpopodium; e.g., *Crepis* (2), *Hypochaeris* (2).

(x) Strongly asymmetric carpopodium represented by a band of non-thickened or thickened cells appearing continuously around the base of cypsela; e.g., *Centaurea* (3), *Cirsium japonicum.*

(xi) Cup-like symmetric or asymmetric carpopodium; e.g., *Centrapalis*, *Mikania.*

(xii) Nearly completed ring-like asymmetric carpopodium with one narrow interruption; e.g., *Lactuca serriola.*

(xiii) Nearly completed ring-like asymmetric carpopodium with one marked interruption; e.g., *Hieracium villosum, Senecio hewrensis.*

(xiv) Interrupted ring-like 2-lobed asymmetric carpopodium or asymmetric carpopodium in 2 opposite sections; e.g., *Berkheya*, *Bidens biternata*, *Helianthus*, *Tithonia* (2).

(xv) One-sided strongly asymmetric carpopodium, e.g., *Catananche.*

Notes on evolution of carpopodium in the Asteraceae

There is no definite relationship of carpopodia among the studied subfamilies of the Asteraceae, since they all have different types of carpopodia. Similarly, different genera of the same tribe may have various types of carpopodia, or may have more or less identical types of carpopodia. Different species of a genus often have unlike types of carpopodia. The carpopodium is very characteristic for each species, the exomorphic expression being gene-controlled. Therefore, the characteristic feature of the abscission zone, or carpopodium, is apparently stable and diacritical for each species.

From the evolutionary point of view, the absence of carpopodium is probably the most primitive state. The poorly differentiated carpopodium is one step further evolved. One-sided carpopodium is probably he highest evolved type. All evolutionary stages of carpopodium are outlined in Table II. From our observations it is obvious that the carpopodium has a value for characterization and delimitation of taxa.

Acknowledgements

We are highly grateful to the Directors and Curators of the following herbaria: AD (Adelaide, South Australia); BRI (Queensland, Australia); LISC (Lisboa, Portugal); NSW (Sydney, Australia); RB (Rio de Janeiro, Brazil); SRGH (Harare, Zimbabwe); TAI (Taipei, Taiwan) and Z (Zurich, Switzerland) who kindly have supplied mature cypselas for this study. The first author is also thankful to the late Prof. A. K. Sarkar and Dr. G. G. Maiti, Department of Botany, University of Kalyani, Kalyani, West Bengal, for valuable guidance during this work.

References

Augier J. & M.-L. du Merac 1951. La phylogenie des Composées. *Rev. Sci.* 3311: 167–182.

Bentham, G. 1873. Notes on the classification, history, and geographical distribution of the Compositae. *J. Linn. Soc. (Bot.)* 13: 355–577.

Blake, S. F. 1918. A revision of the genus *Viguiera. Contr. Gray Herb. n. ser.* 54: 1–205.

Bremer K. 1987. Tribal interrelationships of the Asteraceae. *Cladistics* 3: 210–253.

Bremer, K. 1994. *Asteraceae: Cladistics and Classification*. Timber Press, Portland.

Bremer, K. 1996. Major clades and grades of the Asteraceae. *In*: Hind, D. J. N. & H. J. Beentje (eds.), *Compositae: Systematics*. Proceedings of the International Compositae Conference 1, pp. 1–7. Royal Botanic Gardens, Kew.

Bremer, K. & R. K. Jansen 1992. A new subfamily of the Asteraceae. *Ann. Missouri Bot. Gard.* 79: 414–415.

Bremer K., Jansen, R. K., Karis, P. O., Källersjö, M., Keeley, S. C., Kim, K.-J., Michaels, H. J., Palmer, J. D. & R. S. Wallace 1992. A review of the phylogeny and classification of the Asteraceae. *Nord. J. Bot.* 12: 141–148.

Carlquist, S. 1976. Tribal interrelationships and phylogeny of the Asteraceae. *Aliso* 8: 465–492.

Cron, G. V., Robbertse, P. J. & P. L. D. Vincent 1993. The anatomy of the cypselae of species of *Cineraria* L. (Asteraceae–Senecioneae) and its taxonomic significance. *Bot. J. Linn. Soc.* 112: 319–334.

Cronquist, A. 1955. Phylogeny and taxonomy of the Compositae. *Am. Midl. Nat.* 53: 478–511.

Haque, M. Z. & M. B. E. Godward 1984. New records of the carpopodium in Compositae and its taxonomic use. *Bot. J. Linn. Soc.* 89: 321–340.

Heywood, V. H., Harborne, J. B. & B. L. Turner (eds.) 1977. *The Biology and Chemistry of the Compositae*. Academic Press, London.

Holmgren, P. K., Holmgren, N. H. & L. C. Barnett 1990. *Index Herbariorum. Part I. The herbaria of the World*, 8th edn. Regnum Veg. 120, New York.

Isawumi, M. A., El-Ghazaly, G. & B. Nordenstam 1996. Pollen morphology, floral microcharacters and taxonomy of the genus *Baccharoides* Moench

(Vernonieae: Asteraceae). *Grana* 35: 205–230.

Jansen, R. K., Holsinger, K. E., Michaels, H. J. & J. D. Palmer 1990. Phylogenetic analysis of chloroplast DNA restriction site data at higher taxonomic levels: an example from the Asteraceae. *Evolution* 44: 2089–2105.

Jansen, R. K., Michaels, H. J. & J. D. Palmer 1991. Phylogeny and character evolution in the Asteraceae based on chloroplast DNA restriction site mapping. *Syst. Bot.* 16: 98–115.

Jeffrey, C. 1977. Corolla forms in Compositae – some evolutionary and taxonomic speculations. *In* : Heywood, V. H., Harborne, J. B.& B. L. Turner (eds.),*The Biology and Chemistry of the Compositae* 1: pp. 111–118. Academic Press, London.

Jeffrey, C. 1978. Compositae. *In*: Heywood, V. H. (ed.), *Flowering plants of the world*, pp. 263–268. Mayflower Books, New York.

Jeffrey, C. 1987. Developing descriptors for systematic analyses of Senecioneae (Compositae). *Bot. Jahrb. Syst.* 108: 201–211.

Jeffrey, C. 1992. The tribe Senecioneae (Compositae) in the Mascarene Islands with an annotated world check-list of the genera of the tribe. *Kew Bull.* 47: 49–109.

Johansen, D. A. 1940. *Plant microtechnique*. McGraw Hill, New York.

John, A. 1921. Beiträge zur Kenntnis der Ablösungsvorrichtungen der Kompositenfrüchte. *Beih. Bot. Zentralblatt* 38: 182–203.

Karis, P. O. 1993. Heliantheae sensu lato (Asteraceae), clades and classification. *Pl. Syst. Evol.* 188: 139–195.

Kim, K.-J., Jansen, R. K., Wallace, R. S., Michaels, H. J.& J. D. Palmer 1992. Phylogenetic implications of *rbc*L sequence variation in the Asteraceae. *Ann. Missouri Bot. Gard.* 79: 428–445.

Kim, K.-J. & R. K. Jansen 1995. *ndh*F sequence evolution and the major clades in the sunflower family. *Proc. Nat. Acad. Sci. U.S.A.* 92: 10379–10383.

King, R. M. & H. Robinson 1966. Generic limitations in the *Hofmeisteria* complex (Compositae – Eupatorieae). *Phytologia* 12: 465–476.

King, R. M. & H. Robinson 1979. Studies on Eupatorieae (Asteraceae). CLXXVI. The relationship of *Eupatorium cyrili–nelsonii*. *Phytologia* 44: 84–87.

Leonhardt, R. 1949. Phylogenetisch–systematische Betrachtungen. I. Betrachtungen zur Systematik der Compositen. *Österr. Bot. Zeitschr.* 96: 293–324.

Mattfeld, J. 1923. Compositae. *In*: Pilger, R. (ed.), Plantae Lützelburgianae Brasilienses. *Notizblatt des Botanischen Gartens und Museums zu Berlin* 8: 428–451.

Panero, J. L. & V. A. Funk 2002. Toward a phylogenetic subfamilial classification for the Compositae (Asteraceae). *Proc. Biol. Soc. Washington* 115(4): 909–922.

Robinson, B. L. 1913. Revisions of *Alomia, Ageratum* and *Oxylobus*. *Proceedings of the American Academy of Arts and Sciences* 49: 438–491.

Robinson, H. 1981. A revision of the tribal and subtribal limits of the Heliantheae (Asteraceae). *Smithsonian Contr. Bot.* 51: 1–102.

Robinson, H. 1983. A generic review of the tribe Liabeae (Asteraceae). *Smithsonian Contr. Bot.* 54: 1–69.

Robinson, H. & R. D. Brettell 1973. Studies in the Senecioneae (Asteraceae). IV. The genera *Mesadenia, Syneilesis, Miracacalia, Koyamacalia*, and *Sinacalia*. *Phytologia* 27: 265–276.

Robinson, H. & R. M. King 1977. Eupatorieae – systematic review. *In*: Heywood, V. H., Harborne, J. B. & B. L. Turner (eds.), *The Biology and Chemistry of the Compositae* 1: pp. 437 – 485. Academic Press, London.

Roth, I. 1977. *Handbuch der Pflanzenanatomie*, Spezieller Teil. Band X, Teil I. Gebrüder Borntraeger, Berlin.

Short, P. S., Wilson, K. E. & J. Nailon 1989. Notes on the fruit anatomy of Australian members of the Inuleae (Asteraceae). *Muelleria* 7: 57–79.

Small, J. 1919. *The origin and development of the Compositae*. New Phytol. Reprint 11. William Wesley and Son, London.

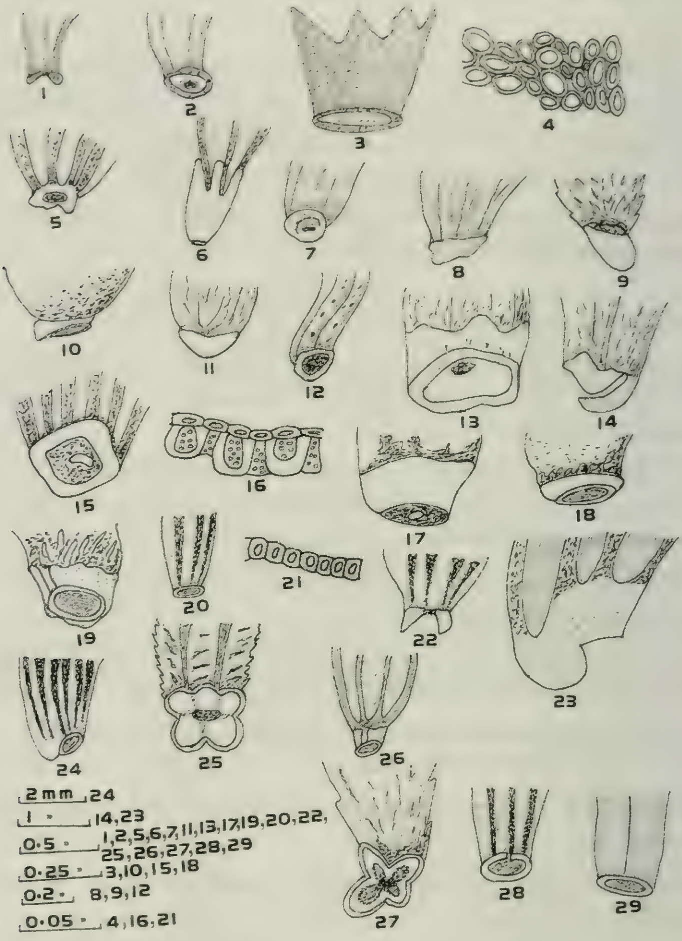
Sundberg, S. 1985. Micromorphological characters as generic markers in the Astereae. *Taxon* 34 : 31–37.

Thorne, R. F. 1983. Proposed new realignments in the angiosperms. *Nord. J. Bot.* 3: 85–117.

Vrgoč, A. 1922. Das Trennungsgewebe einiger offizineller und nichtoffizineller Kompositenblüten. *Berichte der Deutschen Botanischen Gesellschaft* 32: 176–208.

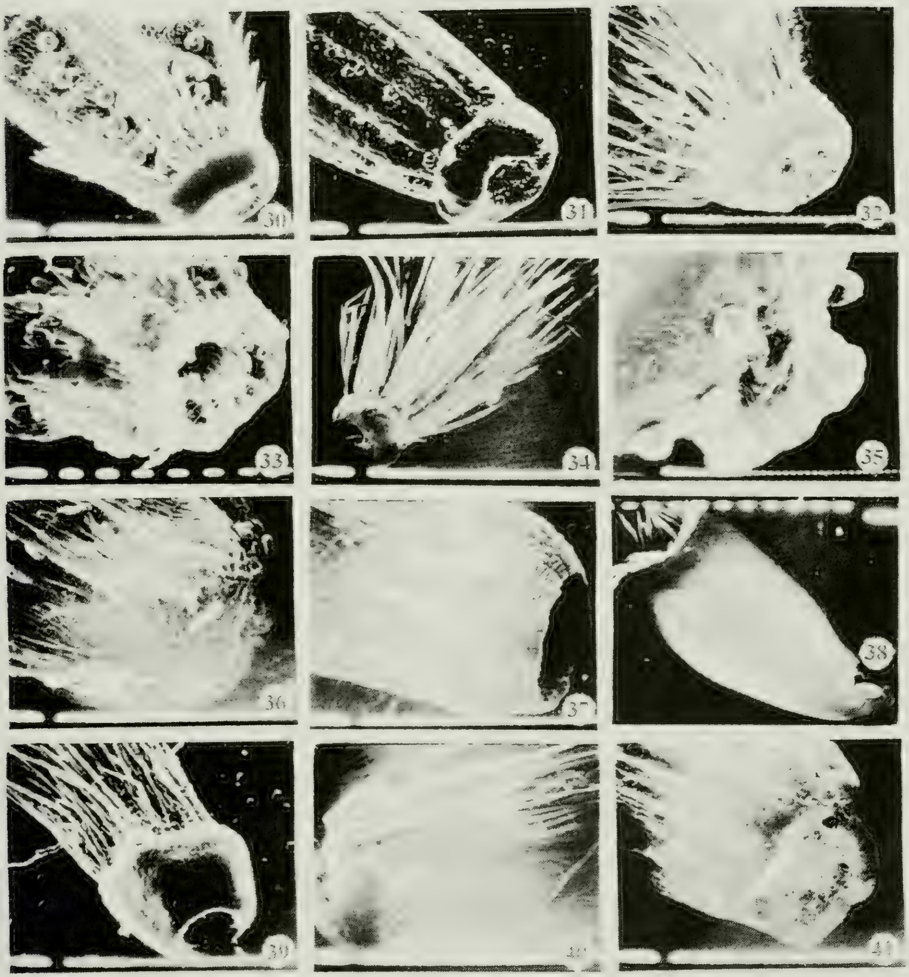
Wagenitz, G. 1976. Systematics and phylogeny of the Compositae (Asteraceae). *Pl. Syst. Evol.* 125: 29–46.

Wetter, M. A. 1983. Micromorphological characters and generic delimitation of some New World Senecioneae (Asteraceae). *Brittonia* 35: 1–22.



Figs. 1–29. Structure of carpopodium in different taxa

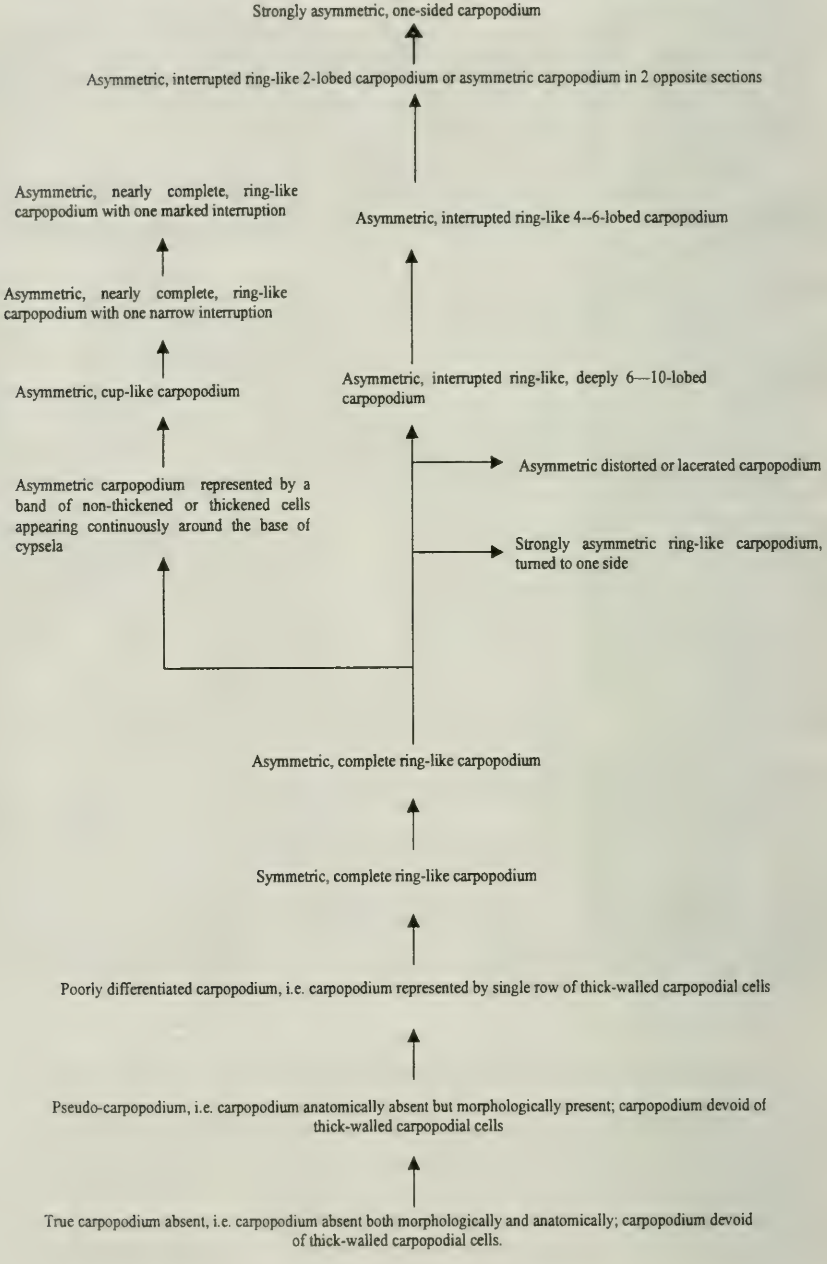
Fig. 1: *Eupatorium cannabinum*. Fig. 2: *Eupatorium chinense* var. *tozanense*. Figs. 3, 4: *Mikania trinervis*. Fig. 5: *Vanillosmopsis capitata*. Fig. 6: *Centrapalis kirkii*. Fig. 7: *Vittadinia gracilis*. Fig.8: *Athrixia phylicoides*. Fig. 9: *Craspedia uniflora*. Fig. 10: *Helichrysum umbraculigerum*. Fig. 11: *Rhodanthe humboldtiana*. Fig. 12: *Cosmos sulphureus*. Fig. 13: *Glossocardia bidens*. Fig. 14: *Tithonia diversifolia*. Figs. 15,16: *Crassocephalum crepidioides*. Fig. 17: *Ligularia dentata*. Fig. 18: *Senecio edgeworthii*. Fig. 19: *Senecio hewrensis*. Figs. 20, 21: *Anthemis tinctoria*. Fig. 22: *Berkheya zeyheri*. Fig. 23: *Centaurea macrocephala*. Fig. 24: *Leuzea rhapontica*. Fig. 25: *Crepis vesicaria*. Fig. 26: *Hieracium villosum*. Fig. 27: *Hypochaeris glabra*. Fig. 28: *Lactuca serriola*. Fig. 29: *Leontodon autumnalis*.



Figs. 30–41. SEM photographs showing the structure of carpopodium

Fig. 30: *Vernonia petersii*, × 200. Fig. 31: *V. senegalensis*, × 100. Fig. 32: *Aster amellus*, × 200. Fig. 33: *Baccharis halimifolia*, × 800. Fig. 34: *Erigeron villarsii*, × 200. Fig. 35: *Gamochaeta pensylvanica*, × 1600. Fig. 36: *Emilia flammea*, × 200. Fig. 37: *Leucanthemum weyrichii*, × 200. Fig. 38: *Centaurea maculosa*, × 50. Fig. 39: *Ainsliaea latifolia*, × 200. Fig. 40: *Catananche caerulea*, × 200. Fig. 41: *Crepis pyrenaica* , × 200.

Table 2. Probable evolution of carpopodium in Asteraceae


Strongly asymmetric, one-sided carpopodium
Asymmetric, interrupted ring-like 2-lobed carpopodium or asymmetric carpopodium in 2 opposite sections
Asymmetric, nearly complete, ring-like carpopodium with one marked interruption
Asymmetric, interrupted ring-like 4--6-lobed carpopodium
Asymmetric, nearly complete, ring-like carpopodium with one narrow interruption
Asymmetric, cup-like carpopodium
Asymmetric, interrupted ring-like, deeply 6—10-lobed carpopodium
Asymmetric distorted or lacerated carpopodium
Asymmetric carpopodium represented by a band of non-thickened or thickened cells appearing continuously around the base of cypsela
Strongly asymmetric ring-like carpopodium, turned to one side
Asymmetric, complete ring-like carpopodium
Symmetric, complete ring-like carpopodium
Poorly differentiated carpopodium, i.e. carpopodium represented by single row of thick-walled carpopodial cells
Pseudo-carpopodium, i.e. carpopodium anatomically absent but morphologically present; carpopodium devoid of thick-walled carpopodial cells
True carpopodium absent, i.e. carpopodium absent both morphologically and anatomically; carpopodium devoid of thick-walled carpopodial cells.

Chromosome numbers in species of *Grindelia* (Asteraceae, Astereae) from the Meseta del Somuncura (Patagonia, Argentina)

A. Bartoli[1] & R. D. Tortosa [1,2]
[1] Laboratorios de Botánica "L. R. Parodi", Facultad de Agronomía,
Universidad de Buenos Aires, Av. San Martín 4453, 1417 Buenos Aires, Argentina
[2] Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

Abstract

Diploid chromosome numbers (2n = 12) for *Grindelia coronensis* A. Bartoli & Tortosa and *G. pygmaea* Cabr. are reported for the first time. Somatic chromosome morphology for both species is described. The karyotype (2n = 12) is composed by 6m+4st+2st-sat. The achene morphology of *G. pygmaea* is communicated for the first time.

Resumen

Se citan por primera vez el número cromosómico diploide de *Grindelia coronensis* A. Bartoli & Tortosa (2n = 12) y de *G. pygmaea* Cabr. (2n = 12). Se describe la morfología de los cromosomas somáticos para ambas especies, cuyo cariotipo está compuesto por 2n=12=6m+4st+2st-sat. Además, se comunica por primera vez la morfología de los aquenios de *G. pygmaea*.

Introduction

Grindelia Willd., a New World genus, is a member of the tribe Astereae with ca. 60 species. In South America the genus is represented by 26 species distributed in Argentina, Bolivia, southern Brazil, Chile, Paraguay and Uruguay. Four species of *Grindelia* live in the Meseta del Somuncura, a vast basaltic plateau, located in northeastern Patagonia: *G. chiloensis* (Corn.) Cabr., *G. coronensis* A. Bartoli & Tortosa, *G. patagonica* A. Bartoli & Tortosa, and *G. pygmaea* Cabr. The last species and *G. coronensis* are endemic to this region (Bartoli & Tortosa 2003). *G. coronensis* originally described from the Cerro Corona, was found later by us in the southern limit of the plateau (Bartoli & Tortosa 44/02-2, BAA) and we also found achenes of *G. pygmaea*, which had not been previously described.

The purpose of this paper is to report for the first time, the chromosome number and chromosome morphology of *Grindelia coronensis* A. BARTOLI & TORTOSA and *Grindelia pygmaea* CABR. and to describe the achene morphology of the latter species.

Methods and Materials

Mitotic chromosomes were studied in root-tip meristems which were pre-treated with 0.004 M 8-hydroxyquinoline at room temperature during 5 h and then fixed in ethanol-lactic acid 5:1. Feulgen staining was used after hydrolysis in 1 M HCl at 60° for 13 min. Chromosome designation follows the terminology recommended by LEVAN & al. (1964). Voucher specimens are deposited at BAA.

Results

Like all species of *Grindelia* investigated, *G. coronensis* and *G. pygmaea* have a basic chromosome number of $x=6$. Chromosome counts revealed the existence of diploid numbers ($2n=12$) in both species (Table 1), with three pairs of metacentric chromosomes (m) and three pairs of subtelocentric chromosomes (st), all of unequal size; the smallest pair with a satellite. The somatic chromosome number and the karyotype of *G. coronensis* and *G. pygmaea* are coincident with the chromosome characteristics found in other South American *Grindelia* species (BARTOLI & TORTOSA 1998).

As far as achene morphology is concerned, there are two different shapes in the genus *Grindelia*: subquadrate (occasionally winged in *G. cabrerae* ARIZA ESPINAR var. *alatocarpa* ARIZA ESPINAR) in North and South American species of *Grindelia* (e.g., *G. camporum* GREENE, *G. mendocina* A. BARTOLI & TORTOSA, *G. pulchella* DUNAL), and compressed and winged, only in South American species that belong to the *Grindelia chiloensis* complex (e.g., *G. coronensis* A. BARTOLI & TORTOSA, *G. patagonica* A. BARTOLI & TORTOSA, *G. chiloensis* (CORN.) CABR.). *Grindelia pygmaea* has subquadrate achenes, ca 2. mm long, straw-coloured.

Discussion

The similarity observed in the chromosome morphology of South American *Grindelia* species suggests that this character could be useful to analyse the relationship between the species of *Grindelia* of North and South America, as well as with the other genera of the *Xanthocephalum* Group (*Isocoma* NUTT., *Olivaea* SCHULTZ-BIP., *Rayjacksonia* HARTMAN & LANE, *Stephanodoria* GREENE, and *Xanthocephalum* WILLD.).

Acknowledgements

The authors acknowledge the support provided by the Myndel Botanica Foundation.

References

Bartoli, A. & R. D. Tortosa 1998. Estudios cromosómicos en especies sudamericanas de *Grindelia* (Astereae, Asteraceae). *Kurtziana* 26: 165–171.

Bartoli, A. & R. D. Tortosa 2003. A new species of *Grindelia* (Asteraceae, Astereae) from the Meseta del Somuncura (Patagonia), Argentina. *Brittonia* 55: 146–149.

Levan, A., Fredga., K. & A. A. Sandberg 1964. Nomenclature for centromeric position on chromosomes. *Hereditas* 52: 201–220.

Table 1. Chromosome numbers in *Grindelia* (Asteraceae)

Taxon	**Locality & collection number**	**Chromosome no. (2n)**
Grindelia coronensis A. Bartoli & Tortosa	Argentina: Río Negro: Dpto. 9 de julio: Meseta del Somuncurá, Cerro Corona. 10 Jan 2002, Bartoli & Tortosa 39/02	12
Grindelia pygmaea Cabr.	Argentina: Río Negro: Dpto. 9 de julio: Meseta del Somuncurá, 10 Jan 2002, Bartoli & Tortosa 54/02	12

On the lectotypification of *Chaetanthera* Ruiz & Pav. (Compositae: Mutisieae)

John F. Pruski [1] & Alison Davies [2]
[1] Missouri Botanical Garden,
P.O. Box 299, St. Louis, MO 63166-0299, U.S.A.
[2] Department Biologie I der LMU München,
Bereich Biodiversitätsforschung: Systematische Botanik,
Menzinger Straße 67, D-80638 München, Germany

Abstract

Chaetanthera ciliata Ruiz & Pav. was cited in Cassini's treatment of *Chaetanthera* in the *Dictionnaire des Sciences Naturelles* and in at least two floristic treatments by Cabrera as the type of the name *Chaetanthera* Ruiz & Pav. The name *Chaetanthera*, however, was not listed as typified in the widely consulted *Index Nominum Genericorum*, in the generic monograph by Cabrera, nor in the Flora of Argentina series. Here, we discuss the nomenclatural history of *Chaetanthera* and agree with the designation by Henri Cassini and Angel Cabrera of *Chaetanthera ciliata* as the lectotype of the name *Chaetanthera.*

Introduction

The South American genus *Chaetanthera* Ruiz & Pav. (Compositae: Mutisieae) (non *Chaetanthera* Nutt. 1834, Compositae: Astereae) was described in 1794. At that time, no species names within the genus were validated. Four years later (Ruiz & Pavón 1798), the first two species of the genus, *C. ciliata* Ruiz & Pav. and *C. serrata* Ruiz & Pav., were simultaneously described. We note that the sole species depicted in the original illustration (Icon. XXIII, drawings on the top of the page numbered 1-14) accompanying the generic description in Ruiz & Pavón (1794) is that named *Chaetanthera ciliata* in 1798.

Chaetanthera was revised by Cabrera (1937), who recognized 37 species accommodated within seven subgenera. The next most complete treatment of the genus is that of Katinas (1996) in the Flora of Argentina series, which treated 20 species of this genus of reduced small annual herbs to stoloniferous perennials that frequent the southern Andes. Until now, however, a generitype has not been widely recognized for the name *Chaetanthera* (viz., Cabrera 1937, Farr & al. 1979: 326, Farr & Zijlstra 1996). Here, preliminary to an anticipated monograph of the genus by the second author, we wish to formally recognize the citations by (1) Henri Cassini in his treatment of *Chaetanthera* in the *Dictionnaire des Sciences Naturelles* (1817: 53) and (2) Angel Cabrera (1971: 311, 1978: 627) in the floras of Patagonia and Jujuy Province of *Chaetanthera ciliata* Ruiz & Pav. as the lectotype of the name *Chaetanthera*.

The two original species of *Chaetanthera* described by Ruiz & Pavón have been variously treated as belonging to: (1) different genera (e.g. Don 1830); (2) different infrageneric taxa of *Chaetanthera* (e.g. Cabrera 1937); or to the same infrageneric taxon of *Chaetanthera* (e.g. Lessing 1832, Candolle 1838).

Don (1830: 234-236) removed *Chaetanthera serrata* to unispecific *Proselia* D. Don leaving *C. ciliata* Ruiz & Pav. and *C. spinulosa* Cass. (named in 1826) as the only two names (at that time) within *Chaetanthera*. That the two original species belong to different groups was more or less echoed 100 years later by Cabrera (1937), who treated *Chaetanthera serrata* within *Chaetanthera* subg. *Proselia* (D. Don) Cabrera and *Chaetanthera ciliata* within *Chaetanthera* subg. *Chaetanthera*. Neither the taxonomic treatments by Don (1830) nor Cabrera (1937), however, technically effected nomenclatural lectotypification of the name *Chaetanthera*. Similarly, Bentham & Hooker (1873: 496) noted that *C. serrata* was the sole species attributed to *Proselia*, but neither did they effect lectotypification of *Chaetanthera*.

Two years after Don described *Proselia,* Lessing (1832) reduced Don's genus into synonymy of *Chaetanthera*. Specifically, Lessing (1832: 113) treated both *Chaetanthera ciliata* Ruiz & Pav. and *C. serrata* Ruiz & Pav. as members of *Chaetanthera* subg. *Chaetanthera*. Candolle (1838: 30-31) followed suite, albeit employing the rank of sections, treating the two original Ruiz & Pavón species within *Chaetanthera* sect. "*Euchaetanthera*."

Cassini (1817: 53) said "la chaétanthère ciliée devra toujours, selon nous, être considérée comme le vrai type du genre." It could be debated whether this entry of Cassini effects lectotypification, but nevertheless Cassini clearly noted that *C. ciliata* was generally preferred as being the "true" type. However, the name *Chaetanthera* was directly cited by Cabrera (1971: 311, 1978: 627) as typified by *Chaetanthera ciliata* Ruiz & Pav., albeit not listed subsequently in the printed and web versions of the essential general reference *Index Nominum Genericorum* (Farr & al. 1979: 326, Farr & Zijlstra 1996). Additionally, in using the "doctrine of residues" (not part of the ICBN, but nevertheless often a useful rule of thumb) as a guide, we can unofficially infer that Don's description of *Proselia* left *C. ciliata* as the sole original Ruiz & Pav. name in *Chaetanthera*, thus unofficially as the type. Moreover, and as also noted by Cabrera (1937: 93-94), the fact that *Chaetanthera ciliata* was the species originally illustrated by Ruiz & Pavón (1794) lends credence to treating the name *Chaetanthera* as being circumscribed with *C. ciliata* as the type as done by Cassini (1817) and Cabrera (1971, 1978).

Conclusion

Two centuries of specialists working with this odd group of small southern Andean Composites have taken *C. ciliata* as the type of the name *Chaetanthera*. *Chaetanthera ciliata*, however, is not listed as the type of *Chaetanthera* in *Index Nominum Genericorum* (Farr et al. 1979, Farr & Zijlstra 1996). The typification of the generic name *Chaetanthera* by *C. ciliata* bears directly upon species assignments to the seven subgenera treated by Cabrera (1937), hence our desire to have the generic name listed as typified by *C. ciliata* in future editions of *Index Nominum Genericorum.*

Thus, in accordance with two centuries of working taxonomic opinion, to maintain current usage of the long-standing infrageneric species allocations within *Chaetanthera*, and to recognize that Ruiz & Pavón illustrated but one species in the *Prodromus* (1794), we agree with the citations of Cassini (1817) and Cabrera (1971, 1978) and recognize *Chaetanthera ciliata* Ruiz & Pav. as lectotype for the name *Chaetanthera* Ruiz & Pav.

Lectotypification

Chaetanthera Ruiz & Pav., Fl. Peru. Chil. Prodr. 106. Icon. XXIII. 1794.

Lectotype (designated by Cassini 1817: 53, Cabrera 1971: 311, 1978: 627): *Chaetanthera ciliata* Ruiz & Pav., Syst. Veg. Peru. Chile. 190. 1798.

Acknowledgements

We would like to thank Kanchi Gandhi, Liliana Katinas, and John McNeill for their help and comments on earlier drafts of this note.

References

Bentham, G. & J. D. Hooker 1873. Compositae. Pp. 163–533. *In*: *Genera Plantarum*, vol. 2, part I. Reeve & Co., London.

Cabrera, A. L. 1937. Revision del género *Chaetanthera* (Compositae). *Rev. Mus. La Plata, Secc. Bot.* 1, 1: 87–210 + Laminae I-IV.

Cabrera, A. L. 1971. Compositae. *In*: M. N. Correa (ed.), *Flora Patagónica*, part 7. Colección Científica del INTA, tomo 8. Buenos Aires, Argentina.

Cabrera, A. L. 1978. Compositae. *In:* A. L. Cabrera (ed.), *Flora de la Provincia de Jujuy, República Argentina*, part 10. Colección Científica del INTA, tomo 13, Buenos Aires, Argentina.

Candolle, A.P. de 1838. *Prodromus systematis naturalis regni vegetabilis,* vol. 7, part I. Treuttel & Würtz, Paris.

Cassini, H. 1817. *Chaetanthera.* Pp. 53–55. *In*: F. Cuvier (ed.), *Dictionnaire des Sciences Naturelles*, ed. 2, vol. 8: CER-CHI. Levrault, Paris.

Don, D. 1830. Descriptions of the new genera and species of the Class Compositae belonging to the Floras of Peru, Mexico, and Chile. *Trans. Linn. Soc. Bot.* 16: 160–303.

Farr, E. R., Leussink, J. A. & F. A. Stafleu 1979. *Index Nominum Genericorum (Plantarum)*. Utrecht Publishers, The Hague.

Farr, E. R. & G. Zijlstra (eds.) 1996. *Index Nominum Genericorum (Plantarum)*, web version posted 9 February 1996. *Index Nominum Genericorum* (ING) – http://rathbun.si.edu/botany/ing/

Katinas, L. 1996. Asteraceae, part 4. Tribu XII. Mutisieae. Subtribu 3. Mutisiinae. *In*: A. T. Hunziker (ed.), *Flora Fanerogámica Argentina* 29(4): 3–40.

Lessing, C.F. 1832. *Synopsis Generum Compositarum, earumque dispositionis novae tentamen monographiis multarum capensium interjectis.* Sumtibus Dunckeri et Humblotii, Berlin.

Ruiz, H. & J. Pavón 1794. *Florae Peruvianae et Chilensis Prodromus*. Sancha, Madrid.

Ruiz, H. & J. Pavón 1798. *Systema Vegetabilium Florae Peruvianae et Chilensis.* Sancha, Madrid.

Typification of the genus *Myriactis* LESS. (Compositae: Astereae)

LI-SONG WANG & HUA PENG
Kunming Institute of Botany, Chinese Academy of Sciences,
Kunming, 650204, China
e-mail: lswang@ns.ibcas.ac.cn

Myriactis LESS. contained two species when published but was not typified. The genus is lectotypified herein, based on *Myriactis nepalensis*.

Keywords: nomenclature, typification, lectotypification, Asteraceae, Compositae, Astereae, *Myriactis*.

Work by the first author during the preparation of Master's dissertation, on the local flora of Mt. Xiaobaicaoling, Yunnan Province, China, showed that there was a problem with the genus *Myriactis*. This genus, with c. 12 species, is distributed from Caucasus through southern and southeastern Asia to New Guinea, with one species in South America (BREMER 1994).

LESSING (1831) established *Myriactis* with two species, *M. nepalensis* and *M. wallichii*, but did not designate the type of the genus. However, he did indicate that he had seen a specimen of each of the species in the HORNEMANN Herbarium, and published them based on the specimens collected by WALLICH (LESSING 1831). The holotypes of *M. nepalensis* and *M. wallichii* have been located in Copenhagen (C). *Myriactis nepalensis* was illustrated in the protologue (LESSING 1831) and it is clear that the generic characters were abstracted from this species.

The genus is lectotypified as follows:

Myriactis LESS., Linnaea 6: 127 (1831). Lectotype (designated here): *Myriactis nepalensis* LESS.

Myriactis nepalensis LESS., Linnaea 6: 128 (1831). Type: [Nepal]: 'Napalia Wallich' [s.n., s.dat.] (holotype C, photograph seen).

Myriactis wallichii LESS., Linnaea 6: 129 (1831). Type: [Nepal]: 'Napalia Wallich'[s.n., s.dat.] (holotype C, photograph seen).

Acknowledgements

We are extremely grateful to Dr D. J. Nicholas Hind (K), for giving much help, and thanks are also due to Prof. Olof Ryding, for providing photographs of the types in C.

References

Bremer, K. 1994. *Asteraceae: Cladistics and Classification.* Timber Press, Portland, Oregon. pp. 426–427.

Lessing, C. F. 1831. *Myriactis. Linnaea* 6: 127–129.

Compositae type images from Munich (M & MSB): the INFOCOMP Project online

A.M.R. Davies, A. Pillukat & P. Bodensteiner
Botanische Staatssammlung München,
Menzinger Straße 67, D-80638 München, Germany
e-mail: daviesam@botanik.biologie.uni-muenchen.de

INFOCOMP uses modern archiving techniques for traditional botanical resources to make them globally available and conserve them for future generations. It involved the digital imaging of Compositae nomenclatural types. An estimated 2,500 Compositae types are held in the Munich public herbarium (M & MSB). Digital images of each type sheet were taken, showing labels, habit and taxonomically relevant details (Figs. 1 & 2). The type material was scientifically evaluated consulting the original species descriptions as well as other resources. The complete searchable database of 2,371 types (ca 16,900 images) and the linked bibliographic information is available on the Internet under http://www.botanischestaatssammlung.de/projects/infocomp.html. The software is displayed optimally when upgrades to Windows Explorer 5.1 or higher are used.

Almost uniquely among such archiving projects, the images on this database were taken freehand using a digital camera, not using a scanner. This has the overwhelming advantage of mobility and, perhaps most importantly in the case of the Compositae, allows for freedom in selecting specific, taxonomically important components to photograph in more detail, and with greater resolution.

The age and importance of the Munich herbarium is reflected in the collectors and authors of names that are found among the Compositae types.

Of the more than 350 different collectors of Compositae types represented in M & MSB the most prolific collectors (and their exsiccatae) include M. Bang, C. F. Ecklon, C. G. T. Kotschy, P. von Lützelburg, C.F.P. von Martius, C.W. von Nägeli, A. Peter, D. Podlech, C.G. Pringle, K.H. Rechinger, & G.W. Schimper.

Among the ca 260 authors of Compositae types represented in M & MSB the most significant include J.G. Baker, P.E. Boissier, A.P. de Candolle, J.M. Greenman, C.W. von Nägeli, A. Peter, K.H. Rechinger, A. Richard, B.L. Robinson, K.H. Zahn.

The genus *Hieracium* s.l. (Hawkweeds) formed a third of the Compositae types, and resulted in a separate publication (Davies et al., in review) dealing with the specific technical and nomenclatural challenges involved.

The continent-based distribution of the types shows that the collections originate from Europe (28%), Africa (24%), South America (20%), North America and Asia (13% each) and lastly Australia & Oceania (2%). This emphasis on Europe is hugely distorted by the *Hieracium* collections. More than 80% of the European collections are *Hieracium* types. Within Africa, the Republic of South Africa, Ethiopia, Namibia, Angola and Madagascar are well represented, while from Asia Afghanistan and Iran are well represented. There are many types from Mexico, Guatemala, the Dominican Republic and Jamaica, all included in "North America" in the database. Brazil, Bolivia, Argentina and Chile are the best represented countries from South America.

Numbers of different types in the database are as follows: holotypes (312), isotypes (938), syntypes (414), lectotypes (20), neotypes (3), types [unspecified] (684).

However, numbers can sometimes mask the existence of interesting material, and there are many collectors and authors whose material is held in M and MSB that do not appear on these lists.

The preliminary statistical results about the types published in DAVIES et al. (2002) are superseded by those in this letter.

The database is searchable using the following search categories: basionym, author, collector, continent and country. Figure 3 shows an example of a search result for *Aspilia riedelii* BAKER.

Feedback has shown that high quality of the images together with the detailed scientific information is much appreciated by taxonomists all over the world.

Any comments, correction or additions to the database would be gratefully received at the following email addresses:

Schuhw@botanik.biologie.uni-muenchen.de
or
daviesam@botanik.biologie.uni-muenchen.de

Acknowledgements

The authors would like to thank their colleagues for support and advice, and the number of synantherologists out there who have contributed praise and comments about the database. INFOCOMP was funded by the BIOLOG program of the German Federal Ministry of Education and Research, Project ID: 01LC9906.

References

DAVIES, A.M.R., BODENSTEINER, P., PILLUKAT, A. & J. GRAU 2002. INFOCOMP - The Compositae Types digital imaging project in Munich. *Sendtnera* 8: 9–20.

DAVIES, A. M. R., PILLUKAT, A. & P. BODENSTEINER. *Hieracium* s.l. – an important part of the INFOCOMP project in Munich. *Biosystematics and Ecology Series*. Österreichische Akademie der Wissenschaften, Wien (in review).

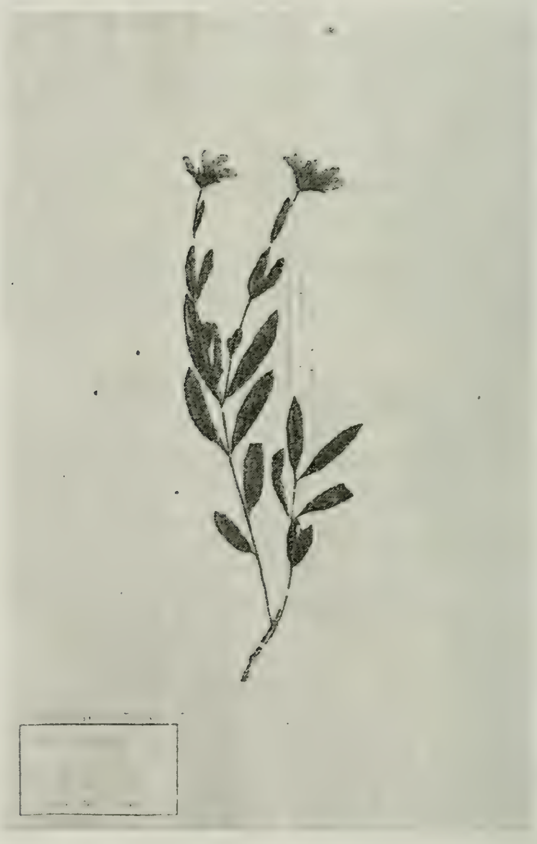


Fig. 1. Type sheet of *Aspilia riedelii* BAKER, a typical example of a collection made by the famous C.F.P. VON MARTIUS in Brazil.

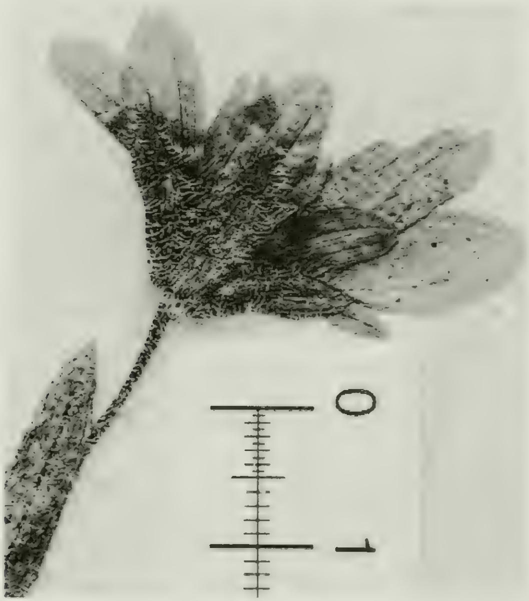
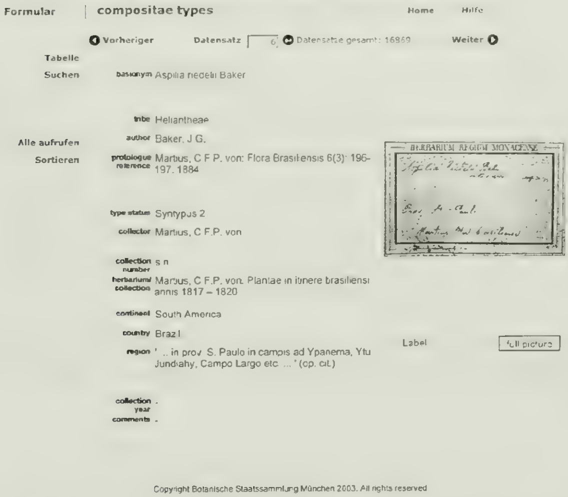


Fig. 2. A detail image of the capitulum.



basionym Aspilia riedelii Baker

tribe Heliantheae

author Baker, J G.

protologue reference Martius, C F P. von: Flora Brasiliensis 6(3): 196-197. 1884

type status Syntypus 2

collector Martius, C F.P. von

collection number s n

herbarium/ collection Martius, C F.P. von. Plantae in itinere brasiliensi annis 1817 – 1820

continent South America

country Brazil

region ' .. in prov S. Paulo in campis ad Ypanema, Ytu Jundiahy, Campo Largo etc ... ' (op. cit.)

collection year -

comments -

Copyright Botanische Staatssammlung München 2003. All rights reserved

Fig. 3. Screen shot of a search result for *Aspilia riedelii* BAKER from the INFOCOMP database http://www.botanischestaatssammlung.de/projects/infocomp.html

Index to Chromosome Numbers in the Asteraceae on the Web

KUNIAKI WATANABE
Department of Biology,
Faculty of Science,
Kobe University
Kobe 657-8501, Japan

A website for Index to Chromosome Numbers in Asteraceae has been established. Please visit the following site:
http://www-asteraceae.cla.kobe-u.ac.jp/index.html

This index to Chromosome Numbers in Asteraceae aims to extract and index original chromosome numbers of naturally occurring and cultivated Asteraceae (Compositae) published throughout the world. The tribal and generic classification and circumscription follow K. BREMER, Asteraceae: Cladistics & Classification, Timber Press, Portland, Oregon (1994). Coverage is intended to be as complete as possible and chromosome counts for past years will add to the database. Russian papers without English summary, however, were excluded in the current version.

I would appreciate to receive any reprints of publications on Compositae chromosomes, as well as suggestions and corrections if you find any inadvertent gaps or mistakes in the database.

Currently the database is on a small computer, and then five persons can access it at the same time. It may become temporarily inaccessible during the occasional maintenance of computer machinery. When you fail to access the site please try later.

Note: In the case of the number of plants examined was not mentioned in the cited paper, it was recorded as one plant in the database. In the case of the collection locality of plants examined was not mentioned in the paper, it was recorded as the nation of author(s), or unknown for some papers, in the database.

This index does not contend with the Index to Plant Chromosome Numbers published by the Missouri Botanical Garden. It is intended to be just convenient for the workers on Compositae.

Call for material of the Inuleae (incl. Plucheeae)

For on ongoing project at the Swedish Museum of Natural History in Stockholm, Sweden, I am at present trying to obtain material of as many species and genera as possible of the Asteraceae-Inuleae (incl. Plucheeae) for DNA analysis. The aim of the project is to resolve the phylogeny of the tribe based on DNA sequence data as a test of earlier work by myself and others, based on morphological data. Right now we have a quite good sampling of taxa and a preliminary tree that will hopefully be published soon, but there are still many taxa that have not been available for study.

I would like to get in contact with colleagues in different parts of the world who may be able to help me obtain material. A pressed specimen as a voucher for the herbarium S in Stockholm, and a few leaves collected in silica gel would be sufficient and much appreciated.

All taxa are of interest, particularly of genera *Pluchea*, *Carpesium*, *Epaltes*, *Stenachaenium*, *Nicolasia*, *Inula*, *Pulicaria*, *Duhaldea*, *Laggera*, *Blumea*, and *Pentanema*, but above all the species belonging to the genera of which we do not have any material at all, viz. *Feddea cubensis*, *Nanothamnus sericeus*, *Merrittia benguetensis*, *Lifago dielsii*, *Triplocephalum holstii*, *Adelostigma senegalensis*, *Delamerea procumbens*, *Pseudoblepharispermum* (2 spp.), and *Monarrhenus* (3 spp.).

Arne A. Anderberg
Department of Phanerogamic Botany,
Swedish Museum of Natural History,
P. O. Box 50007, SE-104 05 Stockholm, Sweden
e-mail: arne.anderberg@nrm.se

BOOK REVIEW

THOMAS M. ANTONIO & SUSANNE MASI: The Sunflower Family In The Upper Midwest: A photographic guide to the Asteraceae in Illinois, Indiana, Iowa, Michigan, Minnesota and Wisconsin 2001. (Cloth with dust jacket, 7 x 10 inches, 419 pages, 544 color photos, 150 range maps, keys, glossary, ISBN 1-883362-11-3). Published by The Indiana Academy of Sciences, Indianapolis (in collaboration with the Chicago Botanical Garden).
http://www.indianaacademyofscience.org/specialpubs.html
$48.00 + postage ($35 for IAS members).

Order through: BILL N. MCKNIGHT, c/o Guerin Catholic High School,
15300 Gray Road, Noblesville, Indiana 46060, USA. (Fax: 317-582-0140).
E-mail: iaspublications@indy.rr.com.

Attention synantherologists and xanthocephologists alike: *The Sunflower Family In The Upper Midwest* by T. ANTONIO & S. MASI is a book which we all will undoubtedly want. Minimally, all of us should peruse this wonderful book. The $48 price (non-Indiana Academy of Science member price) should be the only factor influencing your decision whether or not to purchase *The Sunflower Family In The Upper Midwest.* If you do not purchase this marvelous book, then you will have to be content to adore your institutional copy, and adore it you most definitely will.

Yes, all botanical libraries really need this book, which is certainly among the best-balanced books on regional Compositae available. If you are a beginning midwestern synantherologist, you first need to get a copy of BREMER (*Asteraceae: Cladistics & Classification*, 1994, Timber Press), secondly a subscription to our *Compositae Newsletter*, and thirdly a copy of the great *The Sunflower Family In The Upper Midwest*. Then, with the aid of these three standard references, plus your pencil, hand lens, bottle of safranin, slides, and cover slips, you will be primed to study the most ecologically successful (read: weediest) 10% of the angiosperms known.

The Sunflower Family In The Upper Midwest is largely a popular pictorial (not scientific) book covering composites in central North America (the states of Indiana, Illinois, Michigan, Wisconsin, Iowa, and Minnesota of the United States), which after a succinct 17-page introduction dives right into two-page presentations of very photogenic Compositae (few are cudweeds and ragweeds). These overviews each include several photographs, a distribution map, are attractively laid out, and chock full of a nice mix of well-written popular and scientific information on classification, natural history, garden uses, etc. These two-page treatments constitute the bulk of the book, running from pages 19 to 333. Pages 18 and 334 are blank, as are occasional pages between the fine appendices (but who's counting?).

The crisp reproductions on heavy high quality paper of the spectacular photographs in ANTONIO & MASI (most photographs are by TOM ANTONIO) are the obvious reason we will all want this volume. The introduction includes pictures so sharply focused that you'll be able to see trichomes on *Helianthus* fruits (p. 7), stalked glands on *Silphium* phyllaries (p. 8), disk corolla venation in *Bidens* (p. 10), *Echinacea* pollen (p. 11), and the hairy style shaft of *Vernonia* (p. 12). The species treatments are conveniently grouped by flower color into four sections: (1) white or green; (2) white with yellow centers; (3) yellow; and (4) blue, violet, rose, or pink. Again, it is the photographs for each treatment that will garner the lion's share of the attention. Each treatment includes a habitat photograph on the left-hand page, whereas close-up photographs (as well as the text and map) are presented on the right-hand side.

Following the species treatments and as lagniappe we get pertinent supplemental information. A nice glossary (pp. 335–340), especially molded for novices, is presented. The most technical part of the text (the artificial keys) runs from pages 341 to 378 (generic keys are in Appendix I, and those to species are in Appendix II). Appendix III (pp. 379–381) lists "endangered, threatened, rare, and special concern Asteraceae." Appendix IV (pp. 383–385) is a scientific name pronunciation guide; Appendix V (pp. 387–389) lists plant name authors; and Appendix VI (pp. 391–393) provides data sources for the given species distributions. The Literature Cited (pp. 395–408) lists both popular and technical references, and the Index (pp. 409–419) gives both common and scientific names. To top it all off, this hardbound tome comes replete with a colorful dust jacket and colored endpapers (state and county maps in the front and a 15 cm / 6 inch ruler at the rear). Whew!

While all of the photographs in the species section deserve praise, many images there are of special note. Included among the especially noteworthy reproductions are close-ups (most with black backdrops) of *Prenanthes* styles (p. 35), *Artemisia* pollen (SEM micrograph, p. 37), *Eupatorium* styles (p. 59), larger-than-life *Conyza* rays (p. 101), a *Bidens* achene clearly showing the retrorse barbs of the awns (p. 117), etc. While the close-ups are spectacular, they should perhaps take a back seat to the very three-dimensional lifelike habitat images, again one per species. How authentic are these? Very! Just check out the Dandelion habitat close-up on the waterfront with a city skyline (Chicago?) as its backdrop. Wow!

In summary, the stellar *The Sunflower Family In The Upper Midwest* by ANTONIO & MASI is deserving of more than merely rave reviews. Go purchase your copy today. If you do not get a copy, then to quote BOB DYLAN: "You Ain't Goin' Nowhere."

JOHN F. PRUSKI, Compositae Coordinator of *Flora Mesoamericana*, Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166-0299 U.S.A.

SYNTHESYS
SYNTHESIS OF SYSTEMATIC RESOURCES

EU-funded Integrated Infrastructure Initiative

FRAMEWORK PROGRAMME VI

SYNTHESYS is a five-year project comprising a guest researcher programme and networking activities which together aim to create an integrated **European infrastructure for researchers in the natural sciences**.

The SYNTHESYS guest researcher programme provides funding to scientists (Users) based in European Member and Associated States to undertake short visits (max 60 working days) to utilize the collections, staff expertise and analytical facilities at one of the 20 partner institutions for the purposes of their research. The 20 partner institutions are organised into 11 national TAxonomic Facilities TAFs (list below).

The 11 TAFs represent an unparalleled resource for stimulating research in areas including biological and geological diversity offering:

- Collections amounting to over 337 million natural history specimens, including 3.3 million type specimens
- Internationally renowned skill base
- Physical, chemical, and molecular analyses, and imaging facilities

The second call for applications is now opened. The next deadline will be **Friday 18 March 2005**. The application form and additional information are available at www.synthesys.info.

Further calls will be arranged at approximately 6-month intervals thereafter until 2008.

SYNTHESYS covers the Users' costs for research and accommodation whilst based at the TAF, international travel costs, and a per diem to contribute towards living costs.

SYNTHESYS Partners:

GB-TAF Natural History Museum, Royal Botanic Gardens, Kew, Royal Botanic Garden Edinburgh. *ES-TAF* Museo Nacional de Ciencias, Royal Jardín Botánico Naturales. *DK-TAF* The Natural History Museum of Denmark. *FR-TAF* Museum National d'Histoire Naturelle. *SE-TAF* Naturhistoriska Riksmuseet. *NL-TAF* University van Amsterdam, Nationaal Herbarium Nederland, Centraalbureau voor Schimmelcultures, National Natural History Museum Naturalis. *DE-TAF* Museum fur Naturkunde, Botanischer Garten und Botanisches Museum. *AT-TAF* Naturhistorisches Museum, Wien. *HU-TAF* Hungarian Natural History Museum. *PL-TAF* Museum and Institute of Zoology, Polish Academy of Sciences. *BE-TAF* Royal Belgian Institute of Natural Sciences, Koninklijik Museum voor Midden-Afrika, National Botanic Garden of Belgium.

The SYNTHESYS partners are inviting applications from scientists who have their research basis in the EU member states, or associated or candidate countries of the EU: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Switzerland, Iceland, Israel, Liechtenstein, Norway, Bulgaria, Romania and Turkey.

New taxa published in this issue

Smallanthus riograndensis **C. Mondin, sp. nov.: p. 2**
Smallanthus araucariophilus **C. Mondin, sp. nov.: p. 3**

Elanders Gotab 46882, Stockholm 2004

New York Botanical Garden Library
3 5185 00288 3450

LUESTER T. MERTZ
LIBRARY

FEB 1 7 2005

NEW YORK
BOTANICAL GARDEN